Melanie Jones

From: Keith Frentz <keith.frentz@beca.com>
Sent: Friday, 5 June 2020 10:51 am
To: david@enspire.co.nz
Cc: Matt Hill; David Baker; Theresa Le Bas
Subject: Resource Consent RM19-0663 - Response to Request for Further Information Part 1
Attachments: WKS-15-Workplace-exposure-standards-biological-indices-11th-edition-v2 (2).PDF; WI 12 Phosphine Fumigation not ships version 2 (2).pdf; WI 4A - Aluminium Phosphide Initial Application - Logs v2.2.pdf; SOP 10.2 Pre Inspection of a Vessel for a Phosphine Fumigation V5.1.pdf; SOP 10.4 Phosphine Application to Vessel Holds V10.1.pdf; SOP 10.4 Phosphine Application to Vessel Holds V10.1.pdf; SOP 13.1 Phosphine Residue Removal & Vessel Gas Free V3.1.pdf; Appendix 3-Port Nelson Methyl Bromide Air Quality Assessment.pdf; BOPRC Recapture Monitoring Report - July Final.pdf; Response to BOPRC questions Jan 2020 (002).pdf; Resource Consent RM19-0663 - Response to Request for Further Information Part 1.pdf

Hi David,

As discussed, attached please find Part 1 of our response to the request for further information.

If you have any queries please do not hesitate to contact me.

Best regards

Keith

Ngā Mihi | Kind regards,

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Bay of Plenty Regional Council

5 June 2020

By e-mail

Attention: David Greaves

Dear David

Resource Consent RM19-0663 - Genera Ltd: Response to Request for Further Information

Thank you for the further information request received via email letter dated 16 December 2019 for the consent renewal application associated with Genera's fumigants air discharge consent. We provide an initial response below and will work on the remaining items over the next month.

The following definitions may be useful when considering these responses.

Useful Definitions:

Workplace Exposure Standard (WES):

Workplace exposure standards are a value that refers to the airborne concentration of substances, at which it is believed that nearly all workers can be repeatedly exposed to day after day without coming to harm. The values are normally calculated on work schedules of five shifts of eight hours duration over a 40 hour work week.

Time-Weighted Average (WES-TWA)

Most WES in New Zealand have an eight-hour Time Weighted Average (TWA), representing a work shift of 8 hours over one day. An individual's average exposure over an 8 hour working shift cannot exceed the WES-TWA value for a given substance.

Please see below the responses to your questions;

1. FUMIGANTS

a) **To be completed separately**

b) To be completed separately

c) The application makes reference to the WorkSafe document 'Workplace Exposure Standards and Biological Exposure Indices (November 2018)' with regard to the use of Phosphine. However, it is unclear if the proposed use of Phosphine is to be consistent with this document. Please clarify.

The proposed use of Phosphine by Genera for any fumigations is consistent with the WorkSafe document 'Workplace Exposure Standards and Biological Exposure Indices, 11th Edition (November 2019)'. A copy is attached for your reference.

In addition we provide attached Genera Work Instructions that detail the procedures for working with Phosphine both on-board ships and in containers and chambers on land.

2. CONTAINER FUMIGATIONS

a) Please provide an updated map to show the extent of the container fumigation area.

These areas are shown in the Fumigation Management Plan (FMP) on Figures 2 and 3. They include Zone 7 (Mount Maunganui wharves on application to the Port of Tauranga Ltd only) and Zone 8 (Sulphur Point). Zone 7 includes #5 / #4 Berths and #3 and #9 Sheds. Zone 8 includes Sulphur Point container area, S Block and #20 Shed, MPI Mobile Inspection facility and Empty Container Inspection area.

All Methyl Bromide (MB) container fumigations are subject to recapture technology. In addition, the buffer zones shown on the FMP figures are applied.

The maps of the Port of Tauranga in Figures 1 – 3 show fumigation areas plus eight (8) zones, these are:

Zone 1:	Ship storage area
Zone 2:	The area south of Berth #11 access road
Zone 3:	North of Berth #11 access road to 20m south of Shed 5
Zone 4:	East of Tasman Quay – No fumigation
Zone 5:	#5 Shed – No fumigation
Zone 6:	#6 Berth
Zone 7:	#5 / #4 Berth for containers, sawn timber and vehicles (no logs) including #3 and #9 Shed – Fumigation on application only
Zone 8:	Sulphur Point containers, S Block and #20 Shed, MPI Mobile Inspection facility and Empty Container Inspection

In the event that any fumigation activity is undertaken outside of the fumigation areas shown in Figures 1 – 3 the buffer zones/distances in conditions 5.4, 5.5 and 5.5.1 RC62719 shall apply.

Figure 1: Extract from FMP, section 7.2, page 18

Figure 2: Fumigation Areas, Mount Maunganui Wharves North (Source: Port of Tauranga Fumigation Procedures, Appendix 1)

Figure 3: Fumigation Areas, Sulphur Point (Source: Port of Tauranga Fumigation Procedures, Appendix 1)

Figure 2: Figures 2 and 3 FMP

b) Please provide further information quantifying the concentration of the discharge and if the volume of Methyl Bromide remaining at the time of ventilation varies depending on the material being fumigated. The response should provide a comprehensive assessment of environmental effects resulting from the ventilation of containers and the physical extent of the discharge.

Typically each container is fumigated with approximately 2-6kg of MB. All containers are subject to recapture technology which is used until the concentration of MB in the headspace is less than 5ppm. The recapture equipment is then detached from the container at which point there is a "puff" discharge of residual MB as the container door is opened to allow the equipment to be detached.

An air discharge model has been prepared describing the effects of this discharge for the Port of Nelson and is attached for reference. The discharge is of such a de minimis quantum that the locational difference (different topography and meteorological conditions) does not influence the effects of the discharge.

The modelling report shows that the 99.9th percentile discharge of MB relative to the 1-hour tolerable exposure limit (TEL) extends to the immediate vicinity of the containers and the Fumigation Shed at the Port of Nelson as described for Scenario 2[1] and even then it is not more than a quarter of the TEL concentration of 3,900 µg/m^3. The red shading around the source is less than 800 µg/m^3 and extends for about 3m from the central discharge point). A copy of the contour diagram from the report is also provided below.

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[1] Emission scenario 2 has been used to predict the maximum 1-hour average MB concentrations which could occur outside the Port Security Area. This scenario assumes peak emissions from the three recapture units and from the fumigation shed are occurring continuously for the 1-year simulation period. Emission rates are based on the maximum derived short-term emission rates. The predicted concentrations assume that peak concentration occur during worst case dispersion conditions. (Port Nelson Methyl Bromide Air Quality Assessment, page 18.)

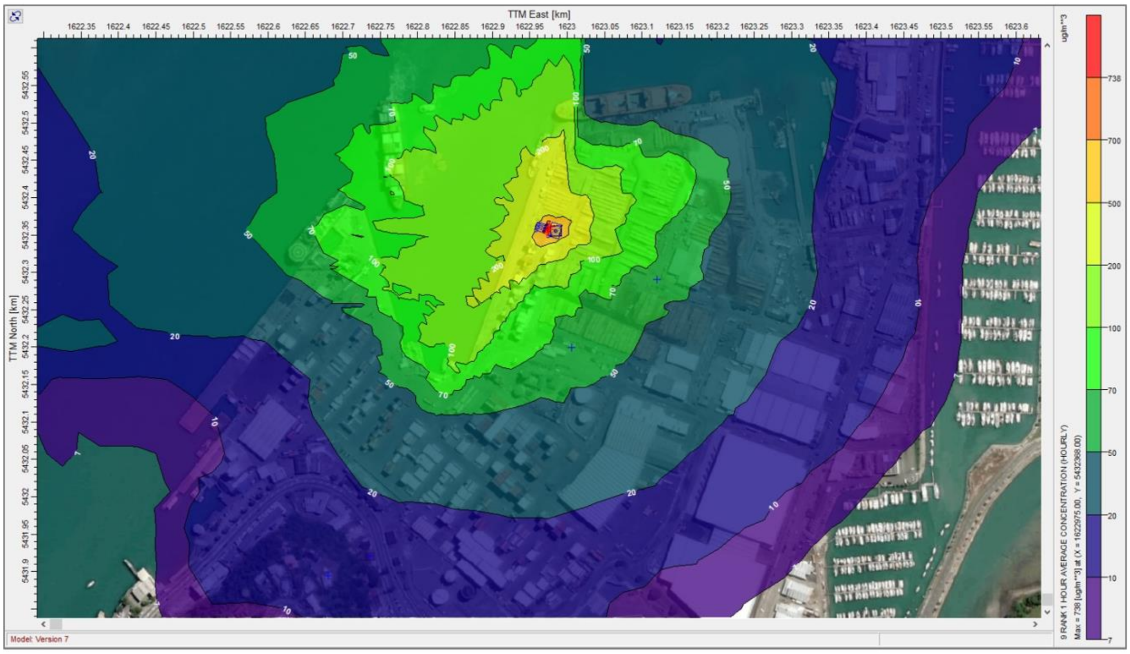

Figure C-4. Predicted 99.9 percentile 1-hour average methyl bromide concentrations (µg/m^3) for Emission Scenario 2

Figure 3: Extract from Appendix C Port Nelson Methyl Bromide Air Quality Assessment

3. EFFECTIVE RECAPTURE

a) Please clarify the methodology for certifying that the effective recapture of Methyl Bromide has been completed to enable venting. Please note that such methodology should be provided for all fumigation activities, including container, log row and break bulk activities.

b) If the methodology includes the monitoring of concentration levels under the sheets, please provide information on the concentration level proposed to be indicative of recapture being completed (including the justification for this concentration).

Effectively there are two methodologies under consideration:

1. Containers
2. Cargo under sheets

<u>Containers</u>

Recapture technology is used on containers until the concentration of MB in the residual airspace is less than 5ppm. This is less than the Worker Exposure Standard (WES) of 5ppm averaged over an 8-hour period as the exposure to a residual discharge is for a very short period of time.

<u>Cargo under sheets</u>

It is not practical to measure the residual concentration of MB under sheets for all events. Therefore, the residual concentration is checked every six months to quantify the length of time recapture technology needs to be used to achieve the Plan Change 13, Bay of Plenty Regional Natural Resources Plan (RNRP) definition of effective recapture, which is:

> ***Effective recapture*** *in relation to fumigation, means a process that captures any fumigant from fumigation enclosures (such as buildings, shipping containers or gas proof sheets covering target product) on activated carbon or other medium so that it is not released into the atmosphere when the fumigation enclosure is ventilated such that the concentration of fumigant (not absorbed by the target product) within the fumigation enclosure at the beginning of the fumigation period is reduced by 80% prior to ventilation of the fumigation enclosure.*

Using these data as a baseline the duration of recapture is interpolated based on volume and dose rate. The methodology for measuring concentrations under sheets is described in Appendix 12 of the FMP and the results are reported to the Bay of Plenty Regional Council.

c) Please provide information on the level of efficiency of the recapture proposed by 'Nessie' and the duration that this recapture is based on?

Nessie operates at a 70% efficiency (MB concentration reduction) rate over a 4 hour period.

d) Please provide further information identifying procedures associated with the storage of fumigants, and the method of disposal for used/recovered fumigants and their associated by-products. Additionally, please clarify if additional resource consents are required for these activities.

1) There is no storage of fumigants on the port, these are stored at Genera's Maru street address which is a Major Hazard Facility and registered with WorkSafe, this is also where EDN would be stored.

   Carbon and liquid solution used for MB recapture (used and fresh) is stored at Maru street. Although there is a quantity retained inside the operational units at the Port.

   Used MB cylinders are taken back to Maru street then exported back to the suppliers, the same would apply with EDN.

   Used empty Aluminium Phosphide cannisters are stored on the Port (at Genera's base at Shed 8). They are allowed to gas off, with controls in place (coned off and monitored, gas levels are low). Once gas free they are then placed in the recycle bin for disposal by the recycling contractor.

   Aluminium phosphide does leave a residue. Ordinarily this goes overseas with logs but if it is applied directly into grain at the Port the residue remains in the grain. The residue is inert once all the phosphine has been released

   Method of disposal for used fumigants (MB):

   For log row fumigation with MB, a liquid scrubbing technology is used for the recapture of the fumigant. By this scrubbing system, MB is chemically destroyed. The disposal of the waste stream is managed by *ChemWaste Ltd*. *ChemWaste*'s post treatment ensures that the treated waste meets the trade waste acceptance criteria and it is disposed of by *ChemWaste* accordingly.

2) Associated by-products (MB):

   The by-products are a mixture of water and chemical products from the process. The composition of the waste stream is commercially sensitive but is of a character that *ChemWaste* is able to dispose of in accordance with their own consents.

3) Additional resource consents:

   The waste stream is managed by *ChemWaste* which is responsible for any licences or consents required. No other resource consents are required.

e) Please provide clarification on if Genera is currently in the process of developing recapture technology associated with the fumigation of ship holds. If this is the case, what recapture efficiency is likely to be achieved and is it anticipated that the recapture of fumigants from ship holds will form part of this resource consent in the future, in what timeframe?

Genera has undertaken trials of recapture technology as it may be applied to ships' holds and will continue to undertake research and development in this area. It will be guided primarily by the EPA in determining the R&D programme for this and also in determining what recapture efficiency meets the EPA and WorkSafe criteria before it can be determined as being "effective". At present it is noted that HRC08002 requires that all fumigation using MB is subject to effective recapture by 28 October 2020 and in the absence of any amendment to this requirement the fumigation of ships' holds without the use of recapture technology could not take place.

As the current application to the BOPRC is for a consent to discharge a contaminant to air it is unclear how the implementation of current or future technology can or should be prescribed at this stage provided the conditions of the consent are met.

4. DISCHARGE DATA

a) Please provide the full 'raw' data set for the historical monitoring undertaken (such as hourly emission records) and update the model using the same. Additionally, figures 5-1 and 5-2 depict monthly averages of TVOCs rather than a record of real time or hourly readings. Please update the figures to reflect the EPA guidance.

b) Please provide all canister Methyl Bromide sampling results that Genera holds, in conjunction with information on associated fumigation activities, locations, meteorological data and PID data, for the previous five-year period or timeframe relied upon in the modelling.

c) Please provide any raw data from the PIDs that fumigation staff wear during fumigation operations for the previous 12-month period or timeframe relied upon in the modelling.

To be completed.

5. CULTURAL EFFECTS

a) Please provide the Cultural Effects Assessment

To be completed.

6. MONITORING

a) Please provide the report of the monitoring prepared for Genera for the BOPRC and referenced in section 4.3.2 as being in Appendix E.

Please find attached the monitoring report referred to,

b) Please provide an assessment of the appropriateness of the 8-hour WES in monitoring the protection of worker health. Additionally, the assessment should provide further modelling to determine probabilistic exposure distances for each fumigant proposed for use on the Port.

It is not appropriate that Genera provide the assessment requested as 8-hour WES is a requirement of WorkSafe NZ as a national regulation. The ESR response to the specific questions below also notes that the setting of exposure limits or standards is generally a regulatory activity, either by the NZEPA or by WorkSafe NZ. Genera is required to implement these regulatory limits and it is not appropriate or necessary for Genera to undertake further assessment. Below is a table that summarises the current exposure limits and the source of the regulations that have determined them.

Fumigant	1-hr TEL		Annual TEL		WES-TWA		Source
	ppm	**mg/m³**	**ppm**	**mg/m³**	**ppm**	**mg/m³**	
Methyl Bromide	1	3.9			5	19	TELs EPA HRC08002. WES-TWA Workplace Exposure Standards and Biological Exposure Indices, 11th Edition, MBIE
Phosphine					0.3	0.42	Workplace Exposure Standards and Biological Exposure Indices, 11th Edition, MBIE
EDN[2]	0.034	0.072			3	6.4	1-hr TEL: NZEPA, 2018 From ESR response to item 7 below. WES-TWA: Workplace Exposure Standards and Biological

[2] EDN is currently being assessed by the NZEPA and WorkSafe NZ and any use of the material will be subject to the regulations in force at the time.

							Exposure Indi es, 11th Edition, MBIE
VaporMate (Ethyl Formate),					100	303	16.7% Ethyl Formate with balance Carbon Dioxide. Workplace Exposure Standards and Biological Exposure Indices, 11th Edition, MBIE, prescribes a TWA-WES of 303 mg/m^3 (100ppm) for ethyl formate.
Pestigas						5	Pestigas is comprised of 0.4% natural pyrethrum and 2.0% Piperonyl Butoxide in Carbon Dioxide Propellant. The Workplace Exposure Standards and Biological Exposure Indices, 11th Edition, MBIE, prescribes a TWA-WES of 5 mg/m^3 for natural pyrethrum.
Synthetic Pyrethroids	A pyrethroid is an organic compound similar to the natural pyrethrins, which are produced by the flowers of pyrethrums (Chrysanthemum cinerariaefolium and C. coccineum). Pyrethroids constitute the majority of commercial household insecticides. In the concentrations used in such products, they may also have insect repellent properties and are generally harmless to humans. Not listed in the Workplace Exposure Standards and Biological Exposure Indices, 11th Edition, MBIE						

7. LIMITS/ESR ASSESSMENT

a) Please review the air quality criteria contained in the ESR assessment, to provide specific consideration for the short-term nature of the fumigation activities and the unique characteristics of the Port of Tauranga site. Currently, it is considered that the ESR assessment draws some general conclusions with regard to exposure limits. However, given the nature of the exposure, being intermittent short-term high exposures, it is considered that further analysis is required to identify the appropriate exposure limits that are applicable in this instance for each of the different fumigants. Such an approach may be the identification of 24-hour, 60-minute and 10-minute exposure limits, although the analysis will require specific assessment of the criteria considered to be appropriate. This analysis is required for each of the fumigants proposed to be used. It is noted that the atmospheric dispersion modelling will require updating to reflect these values.

Response (from ESR letter dated 16 January 2020, attached):

It should be noted that the setting of exposure limits or standards is generally a regulatory activity and, accordingly, the ESR analysis focussed on review of existing relevant regulatory activities, rather than the proposal of novel exposure limits. BOPRC has asked that 24-hour, 60-minute (1-hour) and 10-minute exposure limits be proposed for each of the fumigants considered.

Methyl bromide

24-hour (1.3 mg/m^3) and 1-hour (3.9 mg/m^3) tolerable exposure limits (TELs) for methyl bromide have already been established by the New Zealand Environmental Protection Authority (ERMA, 2009). These exposure limits have regulatory status in New Zealand and, as discussed in the ESR report, are more conservative than exposure limits proposed by some other authorities.

The 1-hour TEL (3.9 mg/m^3) was adopted from the California Environmental Protection Agency (CEPA, 2008) and is based on a study of methyl bromide exposed workers (Watrous, 1942). The CEPA assessment used the modified Haber's Law equation to extrapolate from a lowest observed adverse effect level (LOAEL) of 35 ppm for 2 hours exposure to a LOAEL of 59 ppm for a 1 hour exposure.

The modified Haber's Law equation is:

$$C^n \times t = k$$

Where C is the concentration of the toxicant, t is the exposure duration, n is a substance specific value and k is constant. CEPA used a value of n = 1.33 for methyl bromide. Using the same approach, the LOAEL for a 10-minute exposure would be 227 ppm. CEPA applied a total uncertainty factor of 60 (6x for extrapolation from a LOAEL to a NOAEL, 1x inter-species, 10x intra-species). On this basis a 10-minute TEL consistent with the current NZEPA 1-hour TEL would be 3.78 ppm or 15 mg/m^3.

While other bases for derivation of short-term exposure limits have been considered by other authorities, the 10-minute TEL derived here is consistent with current New Zealand regulation.

Phosphine

NZEPA has set a ceiling TEL for phosphine of 0.01 mg/m^3 (ERMA, 2006). A ceiling value is a concentration that should not be exceeded at any time. However, NZEPA did not establish duration-specific limits.

The US National Research Council Committee on Acute Exposure Guideline Levels (AEGL) concluded that data consistent with the definition of AEGL-1 values were not available for phosphine and AEGL-1 values were not derived. AEGL-1 is the airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic, non-sensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure. AEGL-1 values are usually derived for exposure durations of 10 and 30 minutes and 1, 4 and 8 hours.

CEPA derived an acute reference dose for phosphine of 0.05 ppm (0.07 mg/m^3), based on a NOAEL in a rat lethality study (CEPA, 2014). However, it was noted that the key study did not include testing for sub-lethal neurological effects. It should also be noted that the key study was not a true assessment of acute toxicity, with animals exposed for 6 hours/day, 5 days/week for 13 weeks.

Given the extremely steep dose-response relationship for phosphine, it is probably prudent to consider the NZEPA ceiling TEL as an appropriate exposure limit for all short-term exposure durations.

Ethanedinitrile (EDN)

NZEPA assessed EDN in 2018 (NZEPA, 2018). While NZEPA derived a TEL for long-term bystander exposure (0.034 ppm or 0.072 mg/m^3), short-term exposures was assessed against AEGL-1 values derived by the US National Research Council Committee on Acute Exposure Guideline Levels (NRC, 2014). For exposure durations of 10 minutes and 1 hour the AEGL-1 values were 2.5 and 2.0 ppm, respectively (5.3 and 4.3 mg/m^3 respectively). It should be noted that AEGL-1 values for hydrogen cyanide were adopted for EDN.

No appropriate derivation of a 24-hour exposure limit was found and there is a marked difference between the 8-hour AEGL-1 (1.0 ppm) and the NZEPA chronic TEL (0.034 ppm). Extrapolation from the 8-hour AEGL-1 to a 24-hour limit using the modified Haber's Law equation and a default value of n = 1, results in an estimate for a 24-hour TEL of 0.3 ppm (0.6 mg/m^3). However, it is not recommended that this TEL be applied without toxicological review.

b) Please clarify if the application is seeking to impose a STEL on all fumigants. Additionally, please clarify the formula for determining the STEL in each instance and if the formula includes the use of models based on a distance approach. Note that the analysis required by a) above may address this matter.

Response: (from ESR letter dated 16 January 2020, attached):

As stated previously, it was not the intent of the ESR report to propose or impose exposure limits or standard, but to report what limits were in place and, if possible, what the bases for the limits were. It is likely that phosphine was assigned a WES-STEL due to its extreme acute toxicity, although the reason for the WES-STEL is not stated in the relevant WorkSafe publication.

It is considered that this question has been addressed under the previous section. It should be reiterated that the setting of exposure limits is a responsibility of the regulator and the exposure limits outlined in the previous section should be considered as proposals only.

8. OPERATIONS

a) Please provide a definition for 'fumigation area' and 'fumigation event' that are referred to in the application documents.

The fumigation areas are those areas shown in Figures 1 – 3 of the FMP provided as Appendix C to the application.

Fumigation means the application and ventilation of [a fumigant] for the purpose of destruction of rodents, pests, or other plant or animal organisms or fungi (from HRC08002, Table C4)

A fumigation event is a single fumigation.

b) What are the maximum number and size of log rows proposed to be fumigated over 1 hour and 24 hour periods?

This is highly variable depending on the market conditions, time of year and export requirements. By way of example for the period from 31 July 2019 to 30 August 2019 there were 23 fumigation events under tarpaulins ranging in capacity (or volume) under tarpaulin from 36 m^3 to 13,464 m^3. The average capacity per event was 2,800m^3. The range of events per day was from 1 – 3 and they took place on 14 days of the month. In some months there may be more jobs undertaken (as described in the application) but typically the capacity under the tarpaulin would be within that range.

c) What is the maximum number of log rows that are proposed to be fumigated within a 'fumigation event'?

This will vary depending on the job, the weather and the target market.

d) What is the maximum amount of MB used in a single log row fumigation?

The amount of MB used in a single row fumigation depends on a number of parameters including the volume of the row, the time of year and the market country. To illustrate this point the following table shows a selection of jobs in August 2019, the volume fumigated (which is more relevant than the number of log rows) and the volume of MB used. Note that these were all for log rows under tarpaulin. The fumigation for the 7th August was for 2 log rows while for the 2nd of August with 50% (approx..) more volume had half as much MB applied.

Date	MB Amount (kg)	Capacity of the enclosed space fumigated (m3)
2.8.19	61.0	828.0
5.8.19	12.0	162.0
7.8.19	124.0	576.0
9.8.19	144.0	694.0

e) Please provide further information to outline the procedures that are in place, or proposed, to determine whether the wind speed limit for covering logs or the restrictions on ventilation when temperature inversion conditions are present. This information should include monitoring equipment proposed to be used to provide up to date weather conditions.

The fumigation and recapture team monitors weather conditions using a combination of the POT weather station as reported on their website and experience at the site of each fumigation. It is noted that conditions at the fumigation site are not always the same as that recorded at the weather station. The conditions on site are recorded for every fumigation on the job sheet.

f) Please provide information on the methodology for undertaking shed fumigations, including the frequency, type of fumigant used, volumes and use of recapture technology.

As none of the sheds at the Port of Tauranga are dedicated fumigation sheds it is unusual for fumigation to be undertaken inside sheds at present because of the lack of ambient air movement to disperse residual MB. In the event that it is undertaken then for MB the methodology below is implemented:

- The material to be fumigated is covered with a tarpaulin and sealed with the double water seal.
- Fumigant is applied in the usual way

- Recapture equipment is connected to the target material and recapture is undertaken for a period depending on the type of material and volume under the tarpaulin
- The tarpaulin is removed with the usual signage, monitored safety zone and monitoring in place

g) Please provide the appendices to the Fumigation Management Plan, including the Emergency Response Plan. Additionally, please clarify if regular exercises or meetings are held between Genera and emergency authorities, if so, please provide records of the same.

Appendices provided 14/05/20.

9. MODELLING

To be completed

10. STORAGE AND DISPOSAL OF FUMIGANTS

a) Please provide further information identifying procedures associated with the storage of fumigants, and the method of disposal for used/recovered fumigants and their associated by-products. Additionally, please clarify if additional resource consents are required for these activities.

See also response to item 3(d).

There is no storage of fumigants on the port, these are stored at Genera's Maru street facility which is a Major Hazard Facility and registered with WorkSafe, this is also where EDN would be stored.

Carbon and liquid solution used for MB recapture (used and fresh) is stored at Maru street. Operational quantities are present inside the units at the Port although this is transferred to Maru Street when it is used.

Used MB cylinders are taken back to Maru street then exported back to the suppliers, the same would apply with EDN.

Empty Aluminium Phosphine cannisters are stored on the Port. The residue in the containers (Aluminium phosphide) is inert after the phosphine is released. The empty containers are recycled as required.

Aluminium phosphide has residue, this goes overseas with logs but is also applied directly into grain on port and residue remains in the grain. It becomes inert once all the phosphine has been released

Activities using or storing hazardous substances, or disposing of hazardous waste, are regulated by the Tauranga City Council through the Tauranga City Plan (TCP) and other legislation. The storage, use, transportation or disposal of hazardous substances in the Port Operational Area of the Port Industry Zone is a permitted activity in the TCP.

11. ASSESSMENT OF ALTERNATIVES

a) Please provide a comprehensive assessment of alternatives to the discharge proposed in order to identify the best practicable option as it relates to this application.

The application as a whole discusses, and provides for, the use of alternatives in the fumigation of pests for quarantine and phyto-sanitary purposes. The alternatives to the use of MB that are currently authorised for use include the other fumigants in the application – Phosphine as well as agrichemicals such as Vapormate, Pestigas and synthetic pyrethroids which are permitted in the Regional Air Plan and PC13. It is noted that EDN is not currently authorised for use in New Zealand and it is anticipated that if this is to be authorised as an alternative by the EPA then it would also be subject to this consent albeit through a process of review to align the EPA assessment with the Regional resource management regime.

The ***best practicable option***[3]*, in relation to a discharge of a contaminant or an emission of noise, means the best method for preventing or minimising the adverse effects on the environment having regard, among other things, to—*

(a) the nature of the discharge or emission and the sensitivity of the receiving environment to adverse effects; and

(b) the financial implications, and the effects on the environment, of that option when compared with other options; and

(c) the current state of technical knowledge and the likelihood that the option can be successfully applied

The nature of the discharge from these fumigants to the atmosphere is well documented and provided for in the EPA and WorkSafe controls that apply to their use. Compliance with these controls is the best method of preventing or minimising the adverse effects they may have on the environment and these will, no doubt, be repeated in the conditions of consent (for example, see the table above with the TWA-WES limits provided by MBIE).

Genera has an extensive R&D programme in relation to the development of recapture technology for MB and the use of alternative treatments which has led to the use of Phosphine as an in-transit fumigant in circumstances, and for markets, where it is accepted for use. However, this comes at a significant cost and the R&D and implementation of the alternatives developed must have regard to that cost when considering the implementation of the best practicable option.

The current processes that are applied to MB recapture as described in the application represents the best of current technical knowledge in terms of effective recapture and destruction of MB to chemical components that can be disposed of in accordance with *ChemWaste's* licences and consents. As the R&D develops new technology for recapture will be commissioned.

There is a current focus on reducing the use of MB as a fumigant including the assessment of the use of EDN. When EDN is authorised it will be utilised in accordance with the regulatory requirements of the client markets (they first need to accept it as a fumigant) and the New Zealand regulatory regime. It is noteworthy

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[3] Section 2, Interpretation, Resource Management Act, 1991

that the key difference between EDN and MB is that EDN is not ozone-depleting and is therefore potentially a preferred alternative to the use of MB. However, it is potentially more hazardous (i.e., more toxic and more flammable), if not more so, to human health as MB as an alternative. Extreme caution should be taken with regards to the use of EDN as a better option than MB.

Clause 6(1)(d)(ii) of the Fourth Schedule requires the applicant to include in the assessment of environmental effects an assessment of any alternative methods of discharge including discharge into any other receiving environment. The application assesses this clause and I provide additional assessment below.

The process of fumigation at the POT involves the discharge of the fumigant into an enclosed space and allowing it to permeate and be absorbed by the target material. In the case of MB the material that is not absorbed is then recaptured by way of circulating the air and MB mix in the headspace around the target material through a medium that strips out the MB leaving air behind. It is not proposed at present to recapture EDN as it is not an ODG.

Recapture is the best option for reducing or minimising the discharge of MB to the open air. Five years ago recapture technology was utilised on 20% or less fumigation events whereas today it is utilised on more than 70% of log fumigations and 100% of container and all other fumigations under tarpaulins. At the same time the implementation of phosphine fumigation has further reduced the use of MB by more than 50%. By 28 October 2020, at present, all fumigation events using MB will be required to utilise recapture technology. These are viable alternatives to the methods of discharge that are currently being actively pursued and have resulted in significant reductions in the use and discharge of MB.

The method of discharge is simple; either the container doors are opened or the tarpaulins are removed after recapture. There is no alternative to this method of discharge but conditions are proposed in relation to the removal of tarpaulins that would flatten the discharge curve by increasing the period of time over which the tarpaulins are removed. These are described below:

1. *The removal of tarpaulins from log stacks shall be undertaken in accordance with the following methodology:*
    a. *The tarpaulin is to be removed in three stages:*
        - *Stage 1: Uncover and stop the removal of the tarpaulin at the top of the initial log face. Proceed to Stage 2 when the levels of MB recorded are within safe practices (based on active monitoring) and only after direct approval from the monitoring technician.*
        - *Stage 2: Uncover and stop the removal of the tarpaulin as soon as half the vented log-stack is uncovered. Proceed to stage 3 when the MB levels are within safe practices and only after direct approval from the monitoring technician.*
        - *Stage 3: Full uncovering*
    b. *The rate of ventilation from log-stacks shall be guided by active monitoring from the monitoring technician stationed at the MSZ boundary.*
    c. *A limit of concentration at the boundary of the MSZ shall be determined in relation to the distance to the boundary for each event and if this limit is exceeded then the removal of the tarpaulin shall be slowed or stopped.*

The removal of tarpaulins from other target material shall follow a similar methodology.

Aside from increasing the discharge of MB through the recapture medium, the R&D for which is being worked on, there is no alternative receiving environment for the fumigant than the open air.

In terms of New Zealand's, and our trading partners', border protection and biodiversity there is no alternative to fumigation. The risk to the environment of not fumigating for quarantine pests such as the marmorated stink bug is extremely high.

12. OTHER INFORMATION

a) Paragraph 7.3.10 of the AEE states that the Applicant is currently authorised to use fumigants such as VaporMate in its operations and proposes its use in the future. It is unclear if there is currently an authorisation for the use of VaporMate and as such if it forms part of the 'consented environment' as is implied in the AEE. Please clarify. If vapormate (or pestigas and synthetic pyrethroids) have been used in the past, please provide dates of fumigation activities and quantities of each fumigant used.

Vapormate is authorised for use in New Zealand as a fumigant by the EPA, approval code HSR001655.

Vapormate, along with pestigas and other natural or synthetic pyrethroids are classified as agrichemicals and are therefore permitted under Rule AQ R13 in Plan Change 13 and were permitted under the equivalent rule in the Regional Air Plan. Vapormate is classified as a Recognised As Safe Gas (RASG).

On this basis the use of these agrichemicals are part of the permitted environment and we would request that they are not included in this consent.

b) Resource consent 62719 authorises fumigation activities at the Port of Tauranga and Genera's Maru Street site. The current application does not appear to seek authorisation for fumigation activities at Maru Street. Please confirm that this is the case.

Genera's Maru Street site is not included in this application.

c) Section 2.3.1 of the AEE references Methyl Bromide being a naturally produced gas that generates 1-2 billion kgs/yr. Please cite the original source of this figure and if there are local sources that contribute to concentrations near the Port of Tauranga.

Methyl bromide is present in the atmosphere at a volume mixing ratio of around 7 parts per trillion and its known natural sources include the ocean, biomass burning, fungi, salt marshes, wetlands, rice paddies, mangroves, and tropical rain forests (Encyclopedia of Atmospheric Sciences (Second Edition), 2015).

The volume quoted was sourced from http://www.daff.gov.au/biosecurity/import/general-info/pre-border/afas/methyl-bromide-questions-and-answers

Local sources are likely to be the ocean but this is unlikely to be at a level of detection.

d) Please provide any monitoring data from metres placed in any of the business offices located on the Port?

These areas are not required to be, and have not been, monitored as a requirement of the current consent. Worker protection including that of office workers is achieved by ensuring the WES-TWA is not exceeded at the boundary of our risk area

e) Please provide information/PID measurements on methyl bromide exposure for Genera staff or Port workers for intervals shorter than 8 hours?

There is a fixed monitor for each ventilation downwind on the edge of the monitored safety zone (MSZ). The purpose of the monitor is to show that at the boundary of the MSZ MB levels are below the WES and other workers on the port are not exposed to levels above the WES. The risk area is extended as required to ensure that it is within the WES.

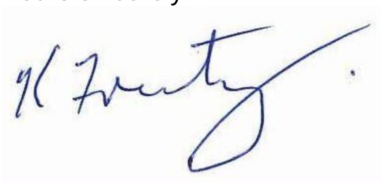
Workers inside the risk area wear respiratory protection. The PIDs are for ensuring those without respiratory protection outside the risk area are not exposed to levels above the WES

f) What Methyl Bromide concentration do the staff personal Methyl Bromide monitors 'alarm' at?

The CUB PiDs worn as part of staff PPE are set to 'alarm' at 5ppm TVOCs.

Further responses to those questions not covered by this letter will be provided as we are able to assemble the information. If you have any queries in the meantime please do not hesitate to contact me.

Yours sincerely



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SPECIAL GUIDE

Workplace exposure standards and biological exposure indices

November 2019

11TH EDITION

New Zealand Government

WORKSAFE
Mahi Haumaru Aotearoa

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Preface

The eleventh 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
23	Table of WES values	– Introduction of (dsen) notation for 'dermal sensitiser', (rsen) notation for 'respiratory sensitiser', and (ifv) notation for 'inhalable fraction and vapour'
24	Table 5: Acrylamide	– Change of WES-TWA to 0.0015mg/m³
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27	Table 5: Carbon disulphide	– Change of WES-TWA to 1ppm
28	Table 5: Chromium (VI) compounds, as Cr	– Change of (sen) to (dsen)
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30	Table 5: *p*-Dichlorobenzene	– Change of WES-TWA to 2ppm – Change of WES-STEL to 10ppm – Introduction of a (skin) notation
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32	Table 5: Dimethyl sulphate	– Change of WES-TWA to 0.01ppm
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33	Table 5: Ethylene oxide	– Introduction of (dsen) and (skin) notations
34	Table 5: Flour dust	– Change of (sen) to (rsen)
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34	Table 5: Glutaraldehyde	– Removal of WES-STEL – Introduction of Ceiling of 0.05ppm – Change of (sen) to (dsen) and (rsen)
34	Table 5: Glycidol (2,3-Epoxy-1-propanol)	– Change of WES-TWA to 2ppm – Introduction of (skin) notation
35	Table 5: Hydroquinone (Dihydroxybenzene)	– Removal of 6.7B notation
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35	Table 5: Inhalable dust (not otherwise classified)	– Introduction of WES-TWA of 10mg/m³
36	Table 5: Isocyanates, all, (as -NCO)	– Change of (sen) to (dsen) and (rsen)

PAGE	TOPIC	CHANGES
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36	Table 5: Limestone	– Change of CAS number to 1317-65-3
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59	Table 6: Styrene	– Change of BEI to 400mg mandelic acid plus phenylglyoxylic acid/g creatinine in urine at end of shift – Introduction of BEI of 40µg/litre styrene in urine at end of shift
59	Table 6: Organophosphates	– Introduced the inclusion of dichlorvos and malathion

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

1.2 Application of WES

1.3 Adjustment of WES for extended workshifts

1.4 Units of measurement

1.5 Mixed exposures

1.6 Aerosols

1.7 Carcinogens

1.8 Skin absorption

1.9 Work load

1.10 Sensitisers

1.11 Simple asphyxiants

1.12 Ototoxins

1.13 Carbon monoxide (CO)

1.1 Introduction

Target audience

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

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
c. A control under section 77 or 77A, or an exposure limit under section 77B, of the HSNO Act
d. A group standard approval issued under section 96B of the HSNO Act.

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.

Many of the WES values in this book were adopted in 2002 from the ACGIH® from values current at that time. Only a small proportion have been reviewed by WorkSafe and its predecessors since then (these are noted with their applicable publication dates). When applying these WES values it must be considered whether or not more up to date WES values from another organisation would be more appropriate to apply for the purposes of managing health risk. Relevant sources of exposure standards include the Gestis substance database, the ACGIH® and SCOEL.

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 (eg from an appropriately qualified occupational hygienist).

When carrying out exposures 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.

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 (eg 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]

[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).

- 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]

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: https://aiha-assets.sfo2.digitaloceanspaces.com/AIHA/resources/Public-Resources/EASC-IHSTAT-V235.xls
- 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).

[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).

- 'Testing Compliance with Occupational Exposure Limits for Airborne Substances' BOHS/NVvA , 2014: https://docplayer.nl/377327-Bohs-nvva-document-testing-compliance-with-occupational-exposure-limits-for-airborne-substances.html

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) (ie 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.

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

- 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 (eg 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.

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

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

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:

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

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 (eg 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 (eg condensation of volatilised solids, or incomplete combustion) and chemical processes (eg 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 1.0g/cm^3 which has the same terminal velocity of settling in still or laminarly flowing air as the particle in question.

Health effects of particulates

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

- infectious
- carcinogenic
- fibrogenic
- allergenic
- irritative.

The total concentration of the substance in air, either in terms of the weight or number of particles per unit volume, is not the only factor influencing its toxic potential. The toxic potential of a substance is influenced by a number of factors including concentration, particle size, mass, surface area and solubility.

Inhalable and respirable dust

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

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

Unless otherwise stated, the WES for dusts refers to inhalable dust. The WES that apply to particulates not otherwise classified apply to particulates that (i) do not have a specified WES, (ii) are insoluble or poorly soluble in water (or, preferably, in aqueous lung fluid if data are available), and (iii) have low toxicity (ie 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]

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 Carcinogens

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

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

Substances which have been identified as confirmed or possible human carcinogens are noted in the WES table (table 5).

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

6.7A – Substances that are known or presumed human carcinogens

a. a substance for which data indicate sufficient evidence in humans of a causal relationship between exposure to the substance and the development of cancer in humans; or
b. a substance for which data indicate sufficient evidence in animals of a causal relationship between exposure to the substance and an increased incidence of tumours; or
c. a substance for which data indicate:
   i. limited evidence in humans of a positive correlation between exposure to the substance and the development of human cancer; and
   ii. limited evidence in animals that exposure to the substance may lead to an increased incidence of tumours.

[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).

6.7B – Substances that are suspected human carcinogens

A substance for which data indicate limited evidence in humans or limited evidence in animals that exposure to the substance may lead to the development of cancer or an increased incidence of tumours, where the strength and weight of the evidence indicate to an expert that the evidence is not sufficient to classify the substance in hazard classification 6.7A.

Substances that are not covered by HSNO legislation, but are carcinogenic to humans, have been noted as such in the WES table (Table 5).

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 5) with a ‘skin’ notation.

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*.

[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.

It should be noted that these ventilation rates represent average values and can vary substantially from individual to individual. Current research on values for peak inspiratory air flow indicate that these are underestimated at present.

ASSESSMENT OF WORK LOAD	AVERAGE VENTILATION RATE LITRES/MINUTE	PEAK INHALATION RATE LITRES/MINUTE
Low (eg writing, typing, small bench tool work, standing while drilling or milling small parts)	11-20	100
Moderate (eg hammering in nails, filing, pneumatic hammering, walking 3.5–5.5km/h)	20-31	150
High (eg carrying heavy loads, shovelling, digging, pushing or pulling heavy cart, walking 5.5–7.0km/h)	31-43	200
Very high (eg 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 5) 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.

1.13 Carbon monoxide (CO)

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

Short-term excursions for CO exposure

CONCENTRATION (PPM)	EXPOSURE PERIOD
200ppm	15 minutes
100ppm	30 minutes
50ppm	60 minutes

TABLE 4: Exposure periods for varying concentrations of carbon monoxide

The CO level should not exceed 400ppm at any time during the day (Ceiling value).

2.0
WES values

IN THIS SECTION:

2.1 Table of WES values

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/m³	Milligrams of substance per cubic metre of air.
(b)	Biological monitoring recommended.
(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. In the absence of specific substances such as chromium, and where conditions do not support the generation of toxic gases, the fume concentration inside the welder's helmet should not exceed 5mg/m³.
6.7A	Confirmed carcinogen
6.7B	Suspected carcinogen
(skin)	Skin absorption
(sen)	Sensitiser
(bio)	Exposure can also be estimated by biological monitoring.
(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
‡	Currently under review
†	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: – Chromium (VI) compounds, as Cr. – Hydrogen sulphide: Interim WES-TWA of 5ppm and STEL of 10ppm. Propose to change to WES-TWA of 1ppm and STEL 5ppm in the year 2022. – Nitrogen dioxide: Interim WES-TWA of 1ppm. Propose to change to WES-TWA of 0.2ppm in the year 2022. – Silica-Crystalline (all forms): Interim WES-TWA of 0.05mg/m³. Propose to review the WES again in the year 2022. – Wood dust, softwood: Interim WES-TWA of 2mg/m³. Propose to change to WES-TWA of 1mg/m³ in the year 2022.

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

Workplace exposure standards

A		**TWA**		**STEL**	
Substance	**CAS #**	**ppm**	**mg/m³**	**ppm**	**mg/m³**
‡ Acetaldehyde 6.7B	[75-07-0]	20		50	
Acetic acid	[64-19-7]	10	25	15	37
Acetic anhydride	[108-24-7]	Ceiling 5ppm (21mg/m³)			
Acetone (bio)	[67-64-1]	500	1,185	1,000	2,375
Acetonitrile (skin)	[75-05-8]	40	67	60	101
Acetylene	[74-86-2]	Simple asphyxiant – may present an explosion hazard			
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		
Acrylamide (skin) 6.7A (2019)	[79-06-1]		0.0015		
Acrylic acid (skin)	[79-10-7]	2	5.9		
Acrylonitrile (skin) 6.7A (2019) (Vinyl cyanide)	[107-13-1]	0.05	0.1		
Allyl alcohol	[107-18-6]	2	4.8	4	9.5
Allyl chloride 6.7B	[107-05-1]	1	3	2	6.0
‡ Allyl glycidyl ether (AGE) (skin)	[106-92-3]	5	23	10	47
α Alumina (Aluminium oxide)	[1344-28-1]		10		
Aluminium, as Al Metal dust Pyro powders Welding fumes Soluble salts Alkyls (not otherwise classified)	[7429-90-5]		 10 5 5 5 2		
Aluminium oxide (α Alumina)	[1344-28-1]		10		
2-Aminoethanol (Ethanolamine)	[141-43-5]	3	7.5	6	15
2-Aminopyridine	[504-29-0]	0.5	2.0		
3-Amino-1,2,4-triazole (Amitrole)	[61-82-5]		0.2		
Amitrole (3-Amino-1,2,4-triazole)	[61-82-5]		0.2		
Ammonia, Anhydrous	[7664-41-7]	25	17	35	24
Ammonium chloride fume	[12125-02-9]		10		20
Ammonium perfluorooctanoate (skin) 6.7B	[3825-26-1]		0.1		
Ammonium sulphamate	[7773-06-0]		10		
Amosite (see Asbestos)					
n-Amyl acetate	[628-63-7]	100	532		
sec-Amyl acetate	[626-38-0]	125	665		

A		TWA		STEL	
Substance	CAS #	ppm	mg/m³	ppm	mg/m³
‡ Aniline and homologues (skin) 6.7B	[62-53-3]	1	4		
Anisidine (*o*-, *p*-isomers) (skin) 6.7B	[29191-52-4]	0.1	0.50		
Antimony and compounds, as Sb	[7440-36-0]		0.5		
Antimony hydride (Stibine)	[7803-52-3]	0.1	0.51		
Antimony trioxide 6.7B (2019)	[1309-64-4]		0.1		
Argon	[7440-37-1]	Simple asphyxiant			
‡ Arsenic and soluble compounds, as As 6.7A	[7440-38-2]		0.05		
Arsine	[7784-42-1]	0.05	0.16		
Asbestos (all forms) confirmed carcinogen		0.1 asbestos fibres per millilitre of air, averaged over an 8-hour period. 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.			
Asphalt (petroleum) fumes	[8052-42-4]		5		
Aspirin (Acetylsalicylic acid)	[50-78-2]		5		
Atrazine	[1912-24-9]		5		
Azinphos-methyl (skin)	[86-50-0]		0.2		

B		TWA		STEL	
Substance	CAS #	ppm	mg/m³	ppm	mg/m³
Barium, soluble compounds, as Ba	[7440-39-3]		0.5		
Barium sulphate	[7727-43-7]		10		
‡ Benzene (skin) 6.7A (2010)	[71-43-2]	1		2.5	
p-Benzoquinone (Quinone)	[106-51-4]	0.1	0.44		
Benzoyl peroxide	[94-36-0]		5		
Benzyl butyl phthalate	[85-68-7]		5		
Benzyl chloride 6.7A	[100-44-7]	1	5.2		

B		TWA		STEL	
Substance	**CAS #**	**ppm**	**mg/m³**	**ppm**	**mg/m³**
Beryllium and compounds, as Be 6.7A (dsen) (2018)	[7440-41-7]		0.0002		
Biphenyl (Diphenyl)	[92-52-4]	0.2	1.3		
Borates, tetra, sodium salts Anhydrous Decahydrate Pentahydrate	[1303-96-4]		 1 5 1		
Boron oxide	[1303-86-2]		10		
Boron tribromide	[10294-33-4]	Ceiling 1ppm (10mg/m³)			
Boron trifluoride	[7637-07-2]	Ceiling 1ppm (2.8mg/m³)			
Bromacil 6.7B	[314-40-9]	1	11		
Bromine	[7726-95-6]	0.1	0.66	0.3	2
Bromine pentafluoride	[7789-30-2]	0.1	0.72		
Bromochloromethane (Chlorobromomethane)	[74-97-5]	200	1,060		
Bromoform (skin)	[75-25-2]	0.5	5.2		
1,3-Butadiene 6.7A (2019)	[106-99-0]	0.05	0.1		
Butane	[106-97-8]	800	1,900		
Butanethiol (Butyl mercaptan)	[109-79-5]	0.5	1.8		
2-Butanone (bio) (Methyl ethyl ketone, MEK)	[78-93-3]	150	445	300	890
2-Butoxyethanol (skin) (Butyl glycol ether)	[111-76-2]	25	121		
n-Butyl acetate	[123-86-4]	150	713	200	950
sec-Butyl acetate	[105-46-4]	200	950		
tert-Butyl acetate	[540-88-5]	200	950		
n-Butyl acrylate (2019)	[141-32-2]	2	11	4	22
n-Butyl alcohol (skin)	[71-36-3]	Ceiling 50ppm (150mg/m³)			
sec-Butyl alcohol	[78-92-2]	100	303		
tert-Butyl alcohol	[75-65-0]	100	303	150	455
Butylated hydroxytoluene (2,6-Di-tert-butyl-p-cresol)	[128-37-0]		10		
n-Butyl glycidyl ether (BGE) (skin) (2019)	[2426-08-6]	0.25	1.33		
Butyl glycol ether (skin) (2-Butoxyethanol)	[111-76-2]	25	121		
n-Butyl lactate	[138-22-7]	5	30		
Butyl mercaptan (Butanethiol)	[109-79-5]	0.5	1.8		
o-sec-Butylphenol (skin)	[89-72-5]	5	31		
p-tert-Butyltoluene	[98-51-1]	10	61	20	121

C		TWA		STEL	
Substance	**CAS #**	**ppm**	**mg/m³**	**ppm**	**mg/m³**
‡ Cadmium and compounds, as Cd 6.7A (bio)	[7440-43-9]		0.01 0.002(r)		
Calcium carbonate	[471-34-1]		10		
Calcium chromate, as Cr 6.7A	[13765-19-0]		0.001		
Calcium cyanamide	[156-62-7]		0.5		
Calcium hydroxide	[1305-62-0]		5		
Calcium oxide	[1305-78-8]		2		
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
Caprolactam (dust vapour)	[105-60-2]	 5	1 23	 10	3 46
Captafol (skin)	[2425-06-1]		0.1		
Captan 6.7B	[133-06-2]		5		
Carbaryl	[63-25-2]		5		
Carbofuran	[1563-66-2]		0.1		
Carbon black 6.7B	[1333-86-4]		3		
Carbon dioxide	[124-38-9]	5,000	9,000	30,000	54,000
Carbon disulphide (skin) (2019)	[75-15-0]	1	3		
Carbon monoxide (bio) See section on carbon monoxide	[630-08-0]	25ppm		Ceiling 400ppm 200ppm 15 min 100ppm 30 min 50ppm 60 min	
Carbon tetrabromide	[558-13-4]	0.1	1.4		
Carbon tetrachloride (skin) 6.7B (Tetrachloromethane)	[56-23-5]	0.1	0.63		
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 (skin) (Pyrocatechol)	[120-80-9]	5	23		
Cellulose (paper fibre)	[9004-34-6]		10		
Cement (dsen) (Portland cement) (2018)	[65997-15-1]		3 1(r)		
Chlorinated diphenyl oxide	[31242-93-0]		0.5		
Chlorine	[7782-50-5]	0.5	1.5	1	2.9
Chlorine dioxide	[10049-04-4]	0.1	0.28		
Chloroacetaldehyde	[107-20-0]	Ceiling 1ppm (3.2mg/m³)			
Chloroacetone (skin)	[78-95-5]	Ceiling 1ppm (3.8mg/m³)			

C		TWA		STEL	
Substance	CAS #	ppm	mg/m³	ppm	mg/m³
α-Chloroacetophenone (Phenacyl chloride)	[532-27-4]	0.05	0.32		
Chloroacetyl chloride (skin)	[79-04-9]	0.05	0.23	0.15	0.69
Chlorobenzene (Monochlorobenzene)	[108-90-7]	10	46		
o-Chlorobenzylidene malononitrile (skin)	[2698-41-1]	Ceiling 0.05ppm (0.39mg/m³)			
Chlorobromomethane (Bromochloromethane)	[74-97-5]	200	1,060		
2-Chloro-1,3-butadiene (skin) (β-Chloroprene)	[126-99-8]	10	36		
Chlorodifluoromethane	[75-45-6]	1,000	3,540		
1-Chloro-2,3-epoxy propane (skin) 6.7A (Epichlorohydrin) (2019)	[106-89-8]	0.05	0.19	0.15	0.58
2-Chloroethanol (skin) (Ethylene chlorohydrin)	[107-07-3]	Ceiling 1ppm (3.3mg/m³)			
Chloroethylene 6.7A (Vinyl chloride) (2017)	[75-01-4]	1	2.6		
Chloroform (skin) 6.7B (Trichloromethane)	[67-66-3]	2	9.9		
bis(Chloromethyl) ether 6.7A	[542-88-1]	0.001	0.0047		
Chloropentafluoroethane	[76-15-3]	1,000	6,320		
Chloropicrin (Nitrochloromethane)	[76-06-2]	0.1	0.67		
β-Chloroprene (skin) (2-Chloro-1,3-butadiene)	[126-99-8]	10	36		
2-Chloropropionic acid (skin)	[598-78-7]	0.1	0.44		
o-Chlorostyrene	[2039-87-4]	50	283	75	425
Chlorosulphonic acid	[7790-94-5]		1		
o-Chlorotoluene	[95-49-8]	50	259		
Chlorpyrifos (skin)	[2921-88-2]		0.2		
Chromite ore processing (Chromate), as Cr 6.7A			0.05		
Chromium metal	[7440-47-3]		0.5		
Chromium (II) compounds, as Cr			0.5		
Chromium (III) compounds, as Cr			0.5		
Chromium (III) compounds, as Cr			0.5		
† Chromium (VI) compounds, as Cr (bio) 6.7A (2018) (dsen) for all chromium (VI) compounds except barium, lead and poorly soluble zinc chromates (skin) for all soluble chromium VI compounds			0.01		

C		TWA		STEL	
Substance	**CAS #**	**ppm**	**mg/m³**	**ppm**	**mg/m³**
Chromyl chloride	[14977-61-8]	0.025	0.16		
Chrysotile (see Asbestos)					
Coal dust			3(r)		
Coal tar pitch volatiles, as benzene solubles 6.7A (PPAH, Particulate polycyclic aromatic hydrocarbons)	[65996-93-2]		0.2		
Cobalt metal dust and fume, as Co (bio) 6.7B (skin) (dsen) (rsen) (2018)	[7440-48-4]		0.02		
Cobalt carbonyl, as Co	[10210-68-1]		0.02		
‡ Copper fume Dusts and mists, as Cu	[7440-50-8]		0.2 1		
Cotton dust, raw			0.2		
Cresol, all isomers (skin)	[1319-77-3]	5	22		
Cristobalite (see Silica-Crystalline)					
Crocidolite (see Asbestos)					
Crotonaldehyde (skin) 6.7B	[4170-30-3]	2	5.7		
Cumene (skin)	[98-82-8]	25	125	75	375
Cyanamide	[420-04-2]		2		
‡ Cyanides, as CN (skin)	[151-50-8]; [143-33-9]		5		
Cyanogen chloride	[506-77-4]	Ceiling 0.3 ppm (0.75 mg/m³)			
Cyclohexane	[110-82-7]	100	350	300	1050
Cyclohexanol (skin)	[108-93-0]	50	206		
Cyclohexanone (skin)	[108-94-1]	25	100		
Cyclohexene	[110-83-8]	300	1,010		
Cyclohexylamine	[108-91-8]	10	41		
Cyclopentadiene	[542-92-7]	75	203		
Cyclopentane	[287-92-3]	600	1,720		

D		TWA		STEL	
Substance	**CAS #**	**ppm**	**mg/m³**	**ppm**	**mg/m³**
2,4-D	[94-75-7]		10		
Diacetone alcohol (4-Hydroxy-4-methyl-2-pentanone)	[123-42-2]	50	238		
Diallyl phthalate	[131-17-9]		5		
1,2-Diaminoethane (skin) (dsen) (rsen) (Ethylenediamine)	[107-15-3]	10	25		

D		TWA		STEL	
Substance	CAS #	ppm	mg/m³	ppm	mg/m³
Diatomaceous earth (not calcined) (see Silica-Amorphous)	[61790-53-2]		10		
Diazinon (skin)	[333-41-5]		0.1		
Diborane	[19287-45-7]	0.1	0.11		
1,2-Dibromoethane (skin) 6.7A (Ethylene dibromide) (2019)	[106-93-4]	0.0003	0.002		
2-N-Dibutylaminoethanol (skin)	[102-81-8]	2	14		
Dibutyl phenyl phosphate (skin)	[2528-36-1]	0.3	3.5		
Dibutyl phthalate	[84-74-2]		5		
Dichloroacetylene 6.7B	[7572-29-4]	Ceiling 0.1ppm (0.39mg/m³)			
o-Dichlorobenzene (skin)	[95-50-1]	Ceiling 50ppm (301mg/m³)			
p-Dichlorobenzene 6.7B (skin) (2019)	[106-46-7]	2	12	10	60
Dichlorodifluoromethane	[75-71-8]	1,000	4,950		
1,3-Dichloro-5,5-dimethyl hydantoin	[118-52-5]		0.2		0.4
1,1-Dichloroethane (Ethylidene chloride)	[75-34-3]	200	810	250	1,010
1,2-Dichloroethane (skin) (Ethylene dichloride)	[107-06-2]	5	21		
1,1-Dichloroethylene (Vinylidene chloride)	[75-35-4]	5	20	20	79
1,2-Dichloroethylene (Acetylene dichloride)	[540-59-0]	200	793		
Dichloroethyl ether (skin)	[111-44-4]	5	29	10	58
Dichlorofluoromethane	[75-43-4]	10	42		
Dichloromethane 6.7B (Methylene chloride)	[75-09-2]	50	174		
1,1-Dichloro-1-nitroethane	[594-72-9]	2	12		
1,2-Dichloropropane (Propylene dichloride) (confirmed carcinogen) (2019)	[78-87-5]	5	23		
Dichloropropene (skin)	[542-75-6]	1	4.5		
2,2-Dichloropropionic acid	[75-99-0]	1	5.8		
Dichlorotetrafluoroethane	[76-14-2]	1,000	6,990		
Dichlorvos (dsen) (skin) 6.7B (2019)	[62-73-7]	0.1	0.90		
Dicyclohexyl phthalate	[84-61-7]		5		
Dicyclopentadiene	[77-73-6]	5	27		
Dicyclopentadienyl iron	[102-54-5]		5		
Diesel Particulate Matter (DPM) as elemental carbon (2016) (diesel engine exhaust is a confirmed carcinogen)			0.1		

D		TWA		STEL	
Substance	CAS #	ppm	mg/m³	ppm	mg/m³
Diethanolamine (skin)	[111-42-2]	3	13		
Diethylamine (skin)	[109-89-7]	10	30	25	75
2-Diethylaminoethanol (skin)	[100-37-8]	10	48		
Diethylene glycol	[111-46-6]	23	101		
Diethylene triamine (skin)	[111-40-0]	1	4.2		
Diethyl ether (Ethyl ether)	[60-29-7]	400	1,210	500	1,520
Di(2-ethylhexyl)phthalate (Di-sec-octyl phthalate)	[117-81-7]		5		10
Diethyl ketone	[96-22-0]	200	705		
Diethyl phthalate	[84-66-2]		5		
‡ Diethyl sulphate (skin) 6.7A	[64-67-5]	0.05	0.32		
Difluorodibromomethane	[75-61-6]	100	858		
‡ Dihydroxybenzene (Hydroquinone)	[123-31-9]		2		
Diisobutyl ketone (2,6-Dimethyl-4-heptanone)	[108-83-8]	25	145		
Diisobutyl phthalate	[84-69-5]		5		
Diisodecyl phthalate	[26761-40-0]		5		
Diisononyl phthalate	[28553-12-0]		5		
Diisococtyl phthalate	[27554-26-3]		5		
Diisopropylamine	[108-18-9]	5	21		
Dimethoxymethane (Methylal)	[109-87-5]	1,000	3,110		
Dimethyl acetamide (skin)	[127-19-5]	10	36		
Dimethylamine	[124-40-3]	10	18		
Dimethylaminoethanol	[108-01-0]	2	7.4	6	22
Dimethylaminobenzene (skin) 6.7B (Xylidine, mixed isomers)	[1300-73-8]	0.5	2.5		
N,N-Dimethylaniline (skin)	[121-69-7]	5	25	10	50
Dimethylbenzene (see Xylene)	Various	50	217		
Dimethyl-1,2-dibromo-2, 2-dichloroethyl phosphate (skin) (Naled)	[300-76-5]		3		
Dimethylether	[115-10-6]	400	766	500	958
N,N-Dimethylethylamine	[598-56-1]	10	30	15	46
Dimethylformamide (skin)	[68-12-2]	10	30		
2,6-Dimethyl-4-heptanone (Diisobutyl ketone)	[108-83-8]	25	145		
1,1-Dimethylhydrazine (skin) 6.7B	[57-14-7]	0.01	0.025		
Dimethylphthalate	[131-11-3]		5		

D		TWA		STEL	
Substance	**CAS #**	**ppm**	**mg/m³**	**ppm**	**mg/m³**
Dimethyl sulphate (skin) 6.7A (2019)	[77-78-1]	0.01	0.05		
Dinitolmide (3,5-Dinitro-o-toluamide)	[148-01-6]		5		
Dinitrobenzene, all isomers (skin)	[528-29-0] [99-65-0] [100-25-4]	0.15	1.0		
‡ Dinitro-o-cresol (skin)	[534-52-1]		0.2		
3,5-Dinitro-o-toluamide (Dinitolmide)	[148-01-6]		5		
Dinonyl phthalate	[84-76-4]		5		
‡ Dioxane (skin) 6.7A	[123-91-1]	25	90		
Diphenyl (Biphenyl)	[92-52-4]	0.2	1.3		
Diphenylamine	[122-39-4]		10		
Diphenylmethane diisocyanate (see Isocyanates)	[101-68-8]		0.02		0.07
Dipropylene glycol methyl ether (skin)	[34590-94-8]	100	606	150	909
Dipropyl ketone	[123-19-3]	50	233		
Diquat	[2764-72-9]		0.5		
Diquat dibromide	[85-00-7]		0.5		
Di-sec-octyl phthalate (Di(2-ethylhexyl)phthalate)	[117-81-7]		5		10
Disulfiram	[97-77-8]		2		
2,6-Di-tert-butyl-p-cresol (Butylated hydroxytoluene)	[128-37-0]		10		
Diuron 6.7B	[330-54-1]		10		
Divinyl benzene	[1321-74-0]	10	53		

E		TWA		STEL	
Substance	**CAS #**	**ppm**	**mg/m³**	**ppm**	**mg/m³**
Emery	[1302-74-5]		10		
Enzymes (see Subtilins)					
Epichlorohydrin (skin) 6.7A (1-Chloro-2,3-epoxy propane) (2019)	[106-89-8]	0.05	0.19	0.15	0.58
1,2-Epoxypropane (dsen) 6.7B (Propylene oxide) (2018)	[75-56-9]	2	4.8		
2,3-Epoxy-1-propanol (skin) 6.7A (Glycidol) (2019)	[556-52-5]	2	6		
Ethane	[74-84-0]	Simple asphyxiant – may present an explosion hazard			
Ethanedinitrile (EDN) (2018)	[460-19-5]	3	6.4	Ceiling 5ppm (10.6mg/m³)	
Ethanethiol (Ethyl mercaptan)	[75-08-1]	0.5	1.3		

E		TWA		STEL	
Substance	CAS #	ppm	mg/m³	ppm	mg/m³
Ethanol (Ethyl alcohol)	[64-17-5]	1,000	1,880		
Ethanolamine (2-Aminoethanol)	[141-43-5]	3	7.5	6	15
2-Ethoxyethanol (skin) (bio) (Glycol monoethyl ester)	[110-80-5]	5	18		
2-Ethoxyethyl acetate (EGEEA) (skin) (bio)	[111-15-9]	5	27		
Ethyl acetate	[141-78-6]	200	720		
Ethyl acrylate (dsen)	[140-88-5]	Ceiling 5ppm (20mg/m³)			
Ethyl alcohol (Ethanol)	[64-17-5]	1,000	1,880		
Ethylamine (skin)	[75-04-7]	10	18		
Ethyl amyl ketone (5-Methyl-3-heptanone)	[541-85-5]	25	131		
Ethyl benzene	[100-41-4]	100	434	125	543
Ethyl bromide (skin) 6.7B	[74-96-4]	5	22		
Ethyl butyl ketone (3-Heptanone)	[106-35-4]	50	234		
Ethyl chloride 6.7B (2019)	[75-00-3]	100	264		
Ethylene	[74-85-1]	Simple asphyxiant			
Ethylene chlorohydrin (skin) (2-Chloroethanol)	[107-07-3]	Ceiling 1ppm (3.3mg/m³)			
Ethylenediamine (skin) (dsen) (rsen) (1,2-Diaminoethane)	[107-15-3]	10	25		
Ethylene dibromide (skin) 6.7A (1,2-Dibromoethane) (2019)	[106-93-4]	0.0003	0.002		
Ethylene dichloride (skin) (1,2-Dichloroethane)	[107-06-2]	5	21		
Ethylene glycol (vapour and mist)	[107-21-1]	Ceiling 50ppm (127mg/m³)			
Ethylene glycol dinitrate (skin)	[628-96-6]	0.05	0.31		
Ethylene glycol methyl ether acetate (skin) (2-Methoxyethyl acetate) (2019)	[110-49-6]	0.1	0.5		
Ethylene glycol isopropyl ether	[109-59-1]	25	106		
Ethyleneimine (skin) 6.7B	[151-56-4]	0.5	0.88		
Ethylene oxide (dsen) (skin) 6.7A (2019)	[75-21-8]	0.1	0.2		
Ethyl ether (Diethyl ether)	[60-29-7]	400	1,210	500	1,520
Ethyl formate	[109-94-4]	100	303		
Ethylidene chloride (1,1-Dichloroethane)	[75-34-3]	200	810	250	1,010
Ethylidene norbornene	[16219-75-3]	Ceiling 5ppm (25mg/m³)			
Ethyl mercaptan (Ethanethiol)	[75-08-1]	0.5	1.3		

E		TWA		STEL	
Substance	**CAS #**	**ppm**	**mg/m³**	**ppm**	**mg/m³**
N-Ethylmorpholine (skin)	[100-74-3]	5	24		
Ethyl silicate	[78-10-4]	10	85		

F		TWA		STEL	
Substance	**CAS #**	**ppm**	**mg/m³**	**ppm**	**mg/m³**
Fenthion (skin)	[55-38-9]		0.2		
Ferrovanadium dust	[12604-58-9]		1		
Fibrous glass dust (see Synthetic mineral fibres)					
Flour dust (rsen) (2018)			1		
Fluorides, as F (bio)			2.5		
Fluorine	[7782-41-4]	1	1.6	2	3.1
Fluorotrichloromethane (Trichlorofluoromethane)	[75-69-4]	Ceiling 1,000ppm (5,620mg/m³)			
‡ Formaldehyde 6.7A (2013)	[50-00-0]	0.5ppm (8 hour shift) 0.33ppm (12 hour shift) Ceiling 1ppm			
Formamide (skin)	[75-12-7]	10	18		
Formic acid	[64-18-6]	5	9.4	10	19
Furfural (skin) 6.7B (2019)	[98-01-1]	0.2	0.8		
Furfuryl alcohol (skin)	[98-00-0]	10	40	15	60

G		TWA		STEL	
Substance	**CAS #**	**ppm**	**mg/m³**	**ppm**	**mg/m³**
Gasoline (Petrol)	[8006-61-9]	300	890	500	1,480
Glass, fibrous or dust (see Synthetic mineral fibres)					
Glutaraldehyde (dsen) (rsen) (2019)	[111-30-8]	Ceiling 0.05ppm (0.21mg/m³)			
Glycerin (mist)	[56-81-5]		10		
Glycidol (skin) 6.7A (2,3-Epoxy-1-propanol) (2019)	[556-52-5]	2	6		
Glycol monoethyl ester (skin) (bio) (2-Ethoxyethanol)	[110-80-5]	5	18		
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

Substance	CAS #	TWA ppm	TWA mg/m^3	STEL ppm	STEL mg/m^3
Halothane	[151-67-7]	0.5			
Helium	[7440-59-7]	Simple asphyxiant			
Heptane (*n*-Heptane)	[142-82-5]	400	1,640	500	2,050
2-Heptanone (Methyl *n*-amyl ketone)	[110-43-0]	50	233		
3-Heptanone (Ethyl butyl ketone)	[106-35-4]	50	234		
Hexachlorocyclopentadiene	[77-47-4]	0.01	0.11		
Hexachloroethane (skin) 6.7B	[67-72-1]	1	9.7		
Hexafluoroacetone (skin)	[684-16-2]	0.1	0.68		
Hexamethylene diisocyanate (see Isocyanates)	[822-06-0]		0.02		0.07
Hexane (*n*-Hexane) (bio)	[110-54-3]	20	72		
Other isomers		500	1,760	1,000	3,500
2-Hexanone (skin) (Methyl *n*-butyl ketone)	[591-78-6]	5	20		
Hexone (Methyl isobutyl ketone)	[108-10-1]	50	205	75	307
sec-Hexyl acetate	[108-84-9]	50	295		
Hexylene glycol	[107-41-5]	Ceiling 25ppm (121mg/m^3)			
Hydrazine (skin) 6.7B (2019)	[302-01-2]	0.0002	0.00026		
Hydrogen	[1333-74-0]	Simple asphyxiant – may present an explosion hazard			
Hydrogenated terphenyls	[61788-32-7]	0.5	4.9		
Hydrogen bromide	[10035-10-6]	Ceiling 3ppm (9.9mg/m^3)			
Hydrogen chloride	[7647-01-0]	Ceiling 5ppm (7.5mg/m^3)			
Hydrogen cyanide (skin)	[74-90-8]	Ceiling 10ppm (11mg/m^3)			
Hydrogen fluoride, as F	[7664-39-3]	Ceiling 3ppm (2.6mg/m^3)			
Hydrogen peroxide	[7722-84-1]	1	1.4		
† Hydrogen sulphide	[7783-06-4]	5	7	10	14
‡ Hydroquinone (Dihydroxybenzene)	[123-31-9]		2		
4-Hydroxy-4-methyl-2-pentanone (Diacetone alcohol)	[123-42-2]	50	238		
2-Hydroxypropyl acrylate (skin)	[999-61-1]	0.5	2.8		

I

Substance	CAS #	TWA ppm	TWA mg/m^3	STEL ppm	STEL mg/m^3
Indium and compounds, as In	[7440-74-6]		0.1		
Inhalable dust (not otherwise classified)			10		
Iodine	[7553-56-2]	Ceiling 0.1ppm (1mg/m^3)			

I		TWA		STEL	
Substance	**CAS #**	**ppm**	**mg/m³**	**ppm**	**mg/m³**
Iodoform	[75-47-8]	0.6	10		
Iodomethane (skin)	[74-88-4]	2	12		
Iron oxide dust and fume (Fe_2O_3), 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
Isobutyl acetate	[110-19-0]	150	713		
Isobutyl alcohol	[78-83-1]	50	152		
Isocyanates, all, (as –NCO) (dsen) (rsen)			0.02		0.07
		Note: These values apply to all isocyanates, including prepolymers, present in the workplace air as vapours, mist or dust.			
Isooctyl alcohol (skin)	[26952-21-6]	50	266		
Isophorone 6.7B	[78-59-1]	Ceiling 5ppm (28mg/m³)			
Isophorone diisocyanate (skin) (see Isocyanates)	[4098-71-9]		0.02		0.07
Isopropyl acetate	[108-21-4]	250	1,040	310	1,290
Isopropyl alcohol	[67-63-0]	400	983	500	1,230
Isopropylamine	[75-31-0]	5	12	10	24
Isopropyl ether	[108-20-3]	250	1,040	310	1,300
Isopropyl glycidyl ether (IGE)	[4016-14-2]	50	238	75	356

K		TWA		STEL	
Substance	**CAS #**	**ppm**	**mg/m³**	**ppm**	**mg/m³**
Kaolin	[1332-58-7]	10mg/m³; and 2mg/m³ (r)			
Ketene	[463-51-4]	0.5	0.86		

L		TWA		STEL	
Substance	**CAS #**	**ppm**	**mg/m³**	**ppm**	**mg/m³**
Lead, inorganic dusts and fumes, as Pb (bio) 6.7B (2019)	[7439-92-1]		0.05		
‡ Lead chromate, as Cr 6.7B	[7758-97-6]		0.05		
Limestone (Calcium carbonate)	[1317-65-3]		10		
Lindane (skin) 6.7B	[58-89-9]		0.1		
Lithium hydride	[7580-67-8]		0.025		
Lithium hydroxide	[1310-65-2]			1	
LPG (Liquefied petroleum gas)	[68476-85-7]	1,000	1,800		

M		TWA		STEL	
Substance	CAS #	ppm	mg/m³	ppm	mg/m³
Magnesite	[546-93-0]		10		
Magnesium oxide fume	[1309-48-4]		10		
Malathion (skin) (ifv) (2019)	[121-75-5]		1		
Maleic anhydride (sen) (ifv) (2019)	[108-31-6]	0.0025	0.01		
Man-made mineral fibres (Synthetic mineral fibres)			1 Respirable fibre per millilitre air and 5mg/m³ Inhalable dust		
Manganese fume, dust and compounds, as Mn (2018)	[7439-96-5]		0.2 0.02(r)		
Manganese cyclopentadienyl tricarbonyl, as Mn (skin)	[12079-65-1]		0.1		
Marble (Calcium carbonate)	[471-34-1]		10		
MDI (see Isocyanates)	[101-68-8]		0.02		0.07
MEK (bio) (Methyl ethyl ketone, 2-Butanone)	[78-93-3]	150	445	300	890
Mercury vapour (as Hg) (skin) (bio) Inorganic compounds (as Hg) Alkyl compounds (as Hg)	[7439-97-6]		0.025 0.025 0.01		
Mesityl oxide	[141-79-7]	15	60	25	100
Methacrylic acid	[79-41-4]	20	70		
Methane	[74-82-8]	Simple asphyxiant – may present an explosion hazard			
Methanethiol (Methyl mercaptan)	[74-93-1]	0.5	0.98		
Methanol (skin), (bio) (Methyl alcohol)	[67-56-1]	200	262	250	328
Methomyl	[16752-77-5]		2.5		
Methoxychlor	[72-43-5]		10		
2-Methoxyethanol (skin) (2019)	[109-86-4]	0.1	0.3		
2-Methoxyethyl acetate (skin) (Ethylene glycol methyl ether acetate) (2019)	[110-49-6]	0.1	0.5		
4-Methoxyphenol	[150-76-5]		5		
Methyl acetate	[79-20-9]	200	606	250	757
Methyl acetylene (Propyne)	[74-99-7]	1,000	1,640		
Methyl acetylene-propadiene mixture (MAPP)	[59355-75-8]	1,000	1,640	1,250	2,050
Methyl acrylate (skin)	[96-33-3]	10	35		
Methylacrylonitrile (skin)	[126-98-7]	1	2.7		
Methylal (Dimethoxymethane)	[109-87-5]	1,000	3,110		
Methyl alcohol (skin) (bio) (Methanol)	[67-56-1]	200	262	250	328
Methylamine	[74-89-5]	10	13		

M		TWA		STEL	
Substance	CAS #	ppm	mg/m³	ppm	mg/m³
Methyl amyl alcohol (skin) (Methyl isobutyl carbinol)	[108-11-2]	25	104	40	167
Methyl n-amyl ketone (2-Heptanone)	[110-43-0]	50	233		
N-Methyl aniline (skin)	[100-61-8]	0.5	2.2		
Methyl bromide (skin)	[74-83-9]	5	19		
Methyl n-butyl ketone (skin) (2-Hexanone)	[591-78-6]	5	20		
Methyl chloride (skin)	[74-87-3]	50	103	100	207
Methyl chloroform (1,1,1-Trichloroethane)	[71-55-6]	125	680		
Methyl 2-cyanoacrylate	[137-05-3]	2	9.1	4	18
Methylcyclohexane	[108-87-2]	400	1,610		
Methylcyclohexanol	[25639-42-3]	50	234		
o-Methylcyclohexanone (skin)	[583-60-8]	50	229	75	344
2-Methylcyclopentadienyl manganese tricarbonyl, as Mn (skin)	[12108-13-3]		0.2		
Methylene bisphenyl isocyanate (see Isocyanates)	[101-68-8]		0.02		0.07
Methylene chloride 6.7B (Dichloromethane)	[75-09-2]	50	174		
4,4-Methylene bis(2-chloroaniline) (skin) 6.7A (MOCA)	[101-14-4]		0.005		
Methylene bis(4-cyclohexylisocyanate) (see Isocyanates)					
4,4-Methylene dianiline (skin) 6.7B (2019)	[101-77-9]	0.002	0.016		
Methyl ethyl ketone (bio) (MEK, 2-Butanone)	[78-93-3]	150	445	300	890
Methyl ethyl ketone peroxide	[1338-23-4]	Ceiling 0.2ppm (1.5mg/m³)			
Methyl formate	[107-31-3]	100	246	150	368
5-Methyl-3-heptanone (Ethyl amyl ketone)	[541-85-5]	25	131		
Methyl iodide (skin) 6.7B	[74-88-4]	2	12		
Methyl isoamyl ketone	[110-12-3]	50	234		
Methyl isobutyl carbinol (skin) (Methyl amyl alcohol)	[108-11-2]	25	104	40	167
Methyl isobutyl ketone (Hexone)	[108-10-1]	50	205	75	307
Methyl isopropyl ketone	[563-80-4]	200	705		
Methyl mercaptan (Methanethiol)	[74-93-1]	0.5	0.98		
Methyl methacrylate (skin)	[80-62-6]	50	208	100	416
Methyl propyl ketone (2-Pentanone)	[107-87-9]	200	705	250	881

M		TWA		STEL	
Substance	CAS #	ppm	mg/m³	ppm	mg/m³
1-Methyl-2-pyrrolidone (skin)	[872-50-4]	25	103	75	309
Methyl silicate	[681-84-5]	1	6		
α-Methyl styrene	[98-83-9]	50	242	100	483
Methyl-tert butyl ether	[1634-04-4]	25	92	75	275
Metribuzin	[21087-64-9]		5		
Mica	[12001-26-2]		3(r)		
Mineral wool fibre (Synthetic mineral fibres)			1 Respirable fibre per millilitre air and 5mg/m³ Inhalable dust		
MOCA (skin) 6.7A (4,4-Methylene bis(2-chloroaniline))	[101-14-4]		0.005		
Molybdenum, as Mo Soluble compounds Insoluble compounds	[7439-98-7]		 5 10		
Monochloroacetic acid (skin)	[79-11-8]	0.3	1.2		
Monochlorobenzene (Chlorobenzene)	[108-90-7]	10	46		
Morpholine (skin)	[110-91-8]	20	71		

N		TWA		STEL	
Substance	CAS #	ppm	mg/m³	ppm	mg/m³
Naled (skin) (Dimethyl-1,2-dibromo-2,2-dichloroethyl phosphate)	[300-76-5]		3		
Naphthalene (skin) 6.7B (2019)	[91-20-3]	0.5	2.6	2	10
Neon	[7440-01-9]	Simple asphyxiant			
Nickel (sen) 6.7B (2018) elemental or metallic inorganic compounds	[7440-02-0]		 0.005(r) 0.02 0.005(r)		
Nicotine (skin)	[54-11-5]		0.5		
Nitric acid	[7697-37-2]	2	5.2	4	10
Nitric oxide	[10102-43-9]	25	31		
p-Nitroaniline (skin)	[100-01-6]		3		
Nitrobenzene (skin) 6.7B	[98-95-3]	1	5		
p-Nitrochlorobenzene (skin) 6.7B	[100-00-5]	0.1	0.64		
Nitrochloromethane (Chloropicrin, Tricholoronitromethane)	[76-06-2]	0.1	0.67		
Nitroethane	[79-24-3]	100	307		
Nitrogen	[7727-37-9]	Simple asphyxiant			

N		TWA		STEL	
Substance	**CAS #**	**ppm**	**mg/m³**	**ppm**	**mg/m³**
† Nitrogen dioxide	[10102-44-0]	1	1.9		
Nitroglycerin (NG) (skin)	[55-63-0]	0.05	0.46		
Nitromethane 6.7B	[75-52-5]	20	50		
1-Nitropropane	[108-03-2]	25	91		
2-Nitropropane 6.7A	[79-46-9]	5	19		
Nitrotoluene (skin)	[88-72-2] [99-08-1] [99-99-0]	2	11		
Nitrous oxide	[10024-97-2]	25	45		
Nonane	[111-84-2]	200	1,050		

O		TWA		STEL	
Substance	**CAS #**	**ppm**	**mg/m³**	**ppm**	**mg/m³**
Octane	[111-65-9]	300	1,400	375	1,750
Oil mist, mineral	[8012-95-1]		5(om)		10
Osmium tetroxide, as Os	[20816-12-0]	0.0002	0.0016		
Oxalic acid	[144-62-7]		1		2
Ozone	[10028-15-6]	Ceiling 0.1ppm (0.20mg/m³)			

P		TWA		STEL	
Substance	**CAS #**	**ppm**	**mg/m³**	**ppm**	**mg/m³**
Paraffin wax fume	[8002-74-2]		2		
Paraquat	[4685-14-7]		0.1(r)		
Particulate polycyclic aromatic hydrocarbons 6.7A (PPAH, Coal tar pitch volatiles)	[65996-93-2]		0.2		
Particulates not otherwise classified			10 3(r)		
PCBs (Polychlorinated Biphenyls)(p)	[1336-36-3]		0.1		
Pentachloronaphthalene	[1321-64-8]		0.5		
Pentachloronitrobenzene	[82-68-8]		0.5		
Pentachlorophenol (skin) 6.7B	[87-86-5]		0.5		
Pentaerythritol	[115-77-5]		10		
Pentane	[109-66-0]	600	1,770	750	2,120
2-Pentanone (Methyl propyl ketone)	[107-87-9]	200	705	250	881
Perchloroethylene (skin) 6.7A (2018) (Tetrachloroethylene)	[127-18-4]	20	136	40	271

P		TWA		STEL	
Substance	CAS #	ppm	mg/m³	ppm	mg/m³
Perchloromethyl mercaptan	[594-42-3]	0.1	0.76		
Perlite	[93763-70-3]		10		
Petrol (Gasoline)	[8006-61-9]	300	890	500	1,480
Phenacyl chloride (α-Chloroacetophenone)	[532-27-4]	0.05	0.32		
‡ Phenol (skin)	[108-95-2]	5			
Phenothiazine	[92-84-2]		5		
m-Phenylenediamine *o*-Phenylenediamine 6.7B *p*-Phenylenediamine (skin)	[108-45-2] [95-54-5] [106-50-3]		0.1 0.1 0.1		
Phenyl ether vapour	[101-84-8]	1	7	2	14
Phenylethylene 6.7B (2018) (Styrene monomer, vinyl benzene)	[100-42-5]	20	85	40	170
Phenyl glycidyl ether (PGE) (skin) (dsen) 6.7B (2019)	[122-60-1]	0.1	0.6		
Phenylhydrazine (skin) 6.7B	[100-63-0]	0.1	0.44		
Phenyl mercaptan	[108-98-5]	0.5	2.3		
Phenylphosphine	[638-21-1]	Ceiling 0.05ppm (0.23mg/m³)			
Phorate (skin)	[298-02-2]		0.05		0.2
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
Phosphoric acid	[7664-38-2]		1		
Phosphorous (yellow)	[7723-14-0]		0.1		
Phosphorous oxychloride	[10025-87-3]	0.1	0.63		
Phosphorous pentachloride	[10026-13-8]	0.1	0.85		
Phosphorous pentasulphide	[1314-80-3]		1		
Phosphorous trichloride	[7719-12-2]	0.2	1.1	0.5	2.8
Phthalic anhydride (skin) (dsen) (rsen) (2019)	[85-44-9]	0.002	0.01		
m-Phthalodinitrile	[626-17-5]		5		
Picloram	[1918-02-1]		10		
Picric acid (2,4,6-Trinitrophenol)	[88-89-1]		0.1		
Pindone (2-Pivaloyl-1,3-indandione)	[83-26-1]		0.1		
Piperazine dihydrochloride	[142-64-3]		5		
Piperidine (skin)	[110-89-4]	1	3.5		
2-Pivaloyl-1,3-indandione (Pindone)	[83-26-1]		0.1		
Plaster of Paris (Calcium sulphate)	[7778-18-9]		10		

P		TWA		STEL	
Substance	**CAS #**	**ppm**	**mg/m³**	**ppm**	**mg/m³**
Platinum metal Soluble salts, as Pt (dsen)	[7440-06-4]		1 0.002		
Polychlorinated Biphenyls (p) (PCBs)	[1336-36-3]		0.1		
Portland cement (dsen) (2018)	[65997-15-1]		3 1(r)		
Potassium hydroxide	[1310-58-3]		Ceiling 2		
PPAH 6.7A (Particulate polycyclic aromatic hydrocarbons, Coal tar pitch volatiles)	[65996-93-2]		0.2		
Precipitated silica (Silica-Amorphous)			10		
Propane	[74-98-6]	Simple asphyxiant – may present an explosion hazard			
Propane-1,2-diol Vapour and particulates Particulates only	[57-55-6]	150	474 10		
Propargyl alcohol (skin)	[107-19-7]	1	2.3		
β-Propiolactone 6.7B	[57-57-8]	0.5	1.5		
Propionic acid	[79-09-4]	10	30		
Propoxur 6.7B	[114-26-1]		0.5		
Propranolol	[525-66-6]		2		6
n-Propyl acetate	[109-60-4]	200	835	250	1,040
n-Propyl alcohol (skin)	[71-23-8]	200	492	250	614
Propylene	[115-07-1]	Simple asphyxiant – may present an explosion hazard			
Propylene dichloride (1,2-Dichloropropane) (confirmed carcinogen) (2019)	[78-87-5]	5	23		
Propylene glycol dinitrate (skin)	[6423-43-4]	0.05	0.34		
Propylene glycol monomethyl ether	[107-98-2]	100	369	150	553
Propylene oxide (dsen) 6.7B (2018) (1,2-Epoxypropane)	[75-56-9]	2	4.8		
n-Propyl nitrate	[627-13-4]	25	107	40	172
Propyne (Methyl acetylene)	[74-99-7]	1,000	1,640		
Pyrethrum (dsen)	[8003-34-7]		5		
Pyridine (skin) 6.7B (2019)	[110-86-1]	1	3.2		
Pyrocatechol (skin) (Catechol)	[120-80-9]	5	23		

Q		TWA		STEL	
Substance	**CAS #**	**ppm**	**mg/m³**	**ppm**	**mg/m³**
Quartz (see Silica-Crystalline)			0.05(r)		
Quinone (*p*-Benzoquinone)	[106-51-4]	0.1	0.44		

R		TWA		STEL	
Substance	**CAS #**	**ppm**	**mg/m³**	**ppm**	**mg/m³**
RDX (skin) (Cyclonite)	[121-82-4]		1.5		
Resorcinol	[108-46-3]	10	45	20	90
Respirable dust (not otherwise classified)			3		
Rhodium metal Insoluble compounds, as Rh Soluble compounds, as Rh	[7440-16-6]		1 1 0.01		
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 process dust Rubber fume (as cyclohexane soluble material)			6 0.6		
Rubber solvent (Naphtha)		400	1,600		

S		TWA		STEL	
Substance	**CAS #**	**ppm**	**mg/m³**	**ppm**	**mg/m³**
Selenium and compounds, as Se	[7782-49-2]		0.1		
Silane (Silicon tetrahydride)	[7803-62-5]	5	6.6		
Silica-Amorphous Diatomaceous earth (not calcined) Precipitated silica Silica gel	[61790-53-2]		 10 10 10		
† Silica-Crystalline (all forms) 6.7A α-quartz and cristobalite are confirmed carcinogens (2016)			0.05(r)		
Silica fume			2(r)		
Silica fused	[60676-86-0]		0.2(r)		
Silica gel (Silica-Amorphous)			10		
Silicon	[7440-21-3]		10		
Silicon carbide	[409-21-2]		10		
Silicon tetrahydride (Silane)	[7803-62-5]	5	6.6		
Silver metal Soluble compounds, as Ag	[7440-22-4]		0.1 0.01		
Soapstone			6 3(r)		
Sodium azide	[26628-22-8]	Ceiling 0.11ppm (0.29mg/m³)			
Sodium bisulphite	[7631-90-5]		5		
Sodium disulphite	[7681-57-4]		5		

S		TWA		STEL	
Substance	**CAS #**	**ppm**	**mg/m³**	**ppm**	**mg/m³**
Sodium fluoroacetate (1080) (skin) (bio)	[62-74-8]		0.05		
Sodium hydroxide	[1310-73-2]		Ceiling 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 6.7A	[7789-06-2]		0.001		
Strychnine	[57-24-9]		0.15		
Styrene monomer 6.7B (2018) (Phenylethylene, vinyl benzene)	[100-42-5]	20	85	40	170
Subtilisins (Proteolytic enzymes, as 100% pure crystalline enzyme) (skin)	[1395-21-7]; [9014-01-1]		Ceiling 0.00006		
Sucrose	[57-50-1]		10		
Sulfotep (skin)	[3689-24-5]		0.2		
Sulphur dioxide (2019)	[7446-09-5]			0.25	0.66
Sulphur hexafluoride	[2551-62-4]	1,000	5,970		
Sulphuric acid 6.7A (2018)	[7664-93-9]		0.1		
Sulphur monochloride	[10025-67-9]	Ceiling 1ppm (5.5mg/m³)			
Sulphuryl fluoride	[2699-79-8]	5	21	10	42
‡ Synthetic mineral fibres (Man-made mineral fibres)			1 Respirable fibre per millilitre air and 5mg/m³ Inhalable dust		

T		TWA		STEL	
Substance	**CAS #**	**ppm**	**mg/m³**	**ppm**	**mg/m³**
2,4,5-T	[93-76-5]		10		
Talc (containing no asbestos fibres)	[14807-96-6]		2(r)		
Talc (containing asbestos fibres)		Use asbestos standards			
Tantalum metal Oxide dusts	[7440-25-7] [1314-61-0]		5 5		
TDI (see Isocyanates)	[584-84-9] [91-08-7]		0.02		0.07
TEDP (skin) (Sulfotep)	[3689-24-5]		0.2		
Tellurium and compounds, as Te	[13494-80-9]		0.1		
Temephos	[3383-96-8]		10		
Terephthalic acid	[100-21-0]		10		

T		**TWA**		**STEL**	
Substance	**CAS #**	**ppm**	**mg/m^3**	**ppm**	**mg/m^3**
Terphenyls	[26140-60-3]	Ceiling 0.5ppm (4.7mg/m^3)			
1,1,1,2-Tetrachloro-2,2-difluoroethane	[76-11-9]	500	4,170		
1,1,2,2-Tetrachloroethane (skin) 6.7B	[79-34-5]	1	6.9		
Tetrachloroethylene 6.7A (skin) (2018) (Perchloroethylene)	[127-18-4]	20	136	40	271
Tetrachloromethane (skin) 6.7B (Carbon tetrachloride)	[56-23-5]	0.1	0.63		
Tetraethyl lead, as Pb (skin), (bio)	[78-00-2]		0.1(b)		
1,1,1,2-Tetrafluoroethane (HCF 134a)	[811-97-2]	1,000			
Tetrahydrofuran (skin) 6.7B	[109-99-9]	100	295		
Tetramethyl succinonitrile (skin)	[3333-52-6]	0.5	2.8		
Tetrasodium pyrophosphate	[7722-88-5]		5		
Tetryl (sen) (2,4,6-Trinitrophenyl-methylnitramine)	[479-45-8]		1.5		
Thallium soluble compounds, as Tl (skin)	[7440-28-0]		0.1		
4,4'-Thiobis(6-tert-butyl-m-cresol)	[96-69-5]		10		
Thioglycolic acid (skin)	[68-11-1]	1	3.8		
Thionyl chloride	[7719-09-7]	Ceiling 1ppm (4.9mg/m^3)			
Thiram (ifv) (2019)	[137-26-8]		0.2		
Tin metal Oxide and inorganic compounds, except SnH4, as Sn Organic compounds, as Sn (skin)	[7440-31-5]		2 2 0.1		 0.2
Titanium dioxide	[13463-67-7]		10		
TNT (skin) (2,4,6-Trinitrotoluene)	[118-96-7]		0.5		
Toluene (skin) (Toluol)	[108-88-3]	50	188		
Toluene-2,4-diisocyanate (see Isocyanates)	[584-84-9]		0.02		0.07
Toluene-2,6-diisocyanate	[91-08-7]		0.02		0.07
o-Toluidine (skin) 6.7B	[95-53-4]	0.2	0.89		
m-Toluidine (skin)	[108-44-1]	2	8.8		
p-Toluidine (skin) 6.7B	[106-49-0]	2	8.8		
Toluol (skin) (Toluene)	[108-88-3]	50	188		
Tributyl phosphate	[126-73-8]	0.2	2.2		
Trichloroacetic acid 6.7B	[76-03-9]	1	6.7		
1,2,4-Trichlorobenzene	[120-82-1]	Ceiling 5ppm (37mg/m^3)			
1,1,1-Trichloroethane (Methyl chloroform)	[71-55-6]	125	680		

T		TWA		STEL	
Substance	CAS #	ppm	mg/m³	ppm	mg/m³
1,1,2-Trichloroethane (skin)	[79-00-5]	10	55		
Trichloroethylene 6.7A (2017)	[79-01-6]	10	55	25	135
Trichlorofluoromethane (Fluorotrichloromethane)	[75-69-4]	Ceiling 1,000ppm (5,620mg/m³)			
Trichloromethane (skin) 6.7B (Chloroform)	[67-66-3]	2	9.9		
Trichloronaphthalene (skin)	[1321-65-9]		5		
Tricholoronitromethane (Chloropicrin, Nitrochloromethane)	[76-06-2]	0.1	0.67		
1,2,3-Trichloropropane (skin) 6.7B (2017)	[96-18-4]	0.005	0.030		
1,1,2-Trichloro-1,2,2-trifluoroethane	[76-13-1]	1,000	7,670	1,250	9,590
Tridymite (see Silica-Crystalline)			0.1(r)		
Triethanolamine	[102-71-6]		5		
Triethylamine (skin)	[121-44-8]	3	12	5	20
Trifluorobromomethane	[75-63-8]	1,000	6,090		
Triglycidyl isocyanurate (TGIC)	[2451-62-9]		0.08		
Trimellitic anhydride (dsen) (rsen)	[522-30-7]	0.005	0.039		
Trimethylamine	[75-50-3]	10	24	15	36
Trimethyl benzene	[25551-13-7]	25	123		
Trimethyl phosphite	[121-45-9]	2	10		
2,4,6-Trinitrophenol (Picric acid)	[88-89-1]		0.1		
2,4,6-Trinitrophenyl-methylnitramine (sen) (Tetryl)	[479-45-8]		1.5		
2,4,6-Trinitrotoluene (skin) (TNT)	[118-96-7]		0.5		
Triorthocresyl phosphate (skin)	[78-30-8]		0.1		
Triphenyl amine	[603-34-9]		5		
Triphenyl phosphate	[115-86-6]		3		
Tripoli (see Silica-Crystalline)			0.1(r)		
Tungsten, as W Insoluble compounds Soluble compounds	[7440-33-7]		5 1		10
Turpentine (wood $C_{10}H_{16}$)	[8006-64-2]	100	556		

U		TWA		STEL	
Substance	CAS #	ppm	mg/m³	ppm	mg/m³
Uranium (natural) soluble and insoluble compounds, as U 6.7A	[7440-61-1]		0.2		

V		TWA		STEL	
Substance	CAS #	ppm	mg/m³	ppm	mg/m³
n-Valeraldehyde	[110-62-3]	50	176		
‡ Vanadium, as V_2O_5 Respirable dust and fume	[1314-62-1]		0.05(r)		
Vegetable oil mists			10		
‡ Vinyl acetate 6.7B	[108-05-4]	10	35	20	70
Vinyl benzene 6.7B (2018) (Styrene monomer, phenylethylene)	[100-42-5]	20	85	40	170
Vinyl bromide 6.7A (2017)	[593-60-2]	0.3	1.30		
Vinyl chloride 6.7A (Chloroethylene) (2017)	[75-01-4]	1	2.6		
Vinyl cyanide (skin) 6.7A (Acrylonitrile) (2019)	[107-13-1]	0.05	0.1		
Vinyl cyclohexene dioxide (skin) 6.7B (2019)	[106-87-6]	0.1	0.6		
Vinylidene chloride (1,1-Dichloroethylene)	[75-35-4]	5	20	20	79
Vinyl toluene	[25013-15-4]	50	242	100	483

W		TWA		STEL	
Substance	CAS #	ppm	mg/m³	ppm	mg/m³
Warfarin	[81-81-2]		0.1		
Welding fume (not otherwise classified) (confirmed carcinogen) (2018)			5(w)		
	When evaluating health risk in relation to welding, exposures to the individual metals, gases and products of combustion should also be assessed. This is because many of the constituent metals, and other relevant substances that may be found in a welding plume have workplace exposure standards that are significantly lower than 5mg/m³, the WES-TWA for Welding fume (not otherwise classified), and may significantly contribute to health risk.				
White spirits (Stoddard solvent)	[8052-41-3]	100	525		
Wood dust, hard (sen) (confirmed/suspected carcinogen depending on hard wood type) (2019)			0.5		
† Wood dust, soft (2019)			2		

WOOD SPECIES: HARDWOOD AND SOFTWOOD CLASSIFICATION LIST

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

X		TWA		STEL	
Substance	CAS #	ppm	mg/m³	ppm	mg/m³
Xylene (*o*-, *m*-, *p*-isomers)	[1330-20-7] [95-47-6] [108-38-3] [106-42-3]	50	217		
m-Xylene a,a'-diamine (skin)	[1477-55-0]		Ceiling 0.1		
Xylidine mixed isomers (skin) 6.7B	[1300-73-8]	0.5	2.5		

Y		TWA		STEL	
Substance	CAS #	ppm	mg/m³	ppm	mg/m³
Yttrium metal and compounds, as Y	[7440-65-5]		1		

Z		TWA		STEL	
Substance	CAS #	ppm	mg/m³	ppm	mg/m³
Zinc chloride fume	[7646-85-7]		1		2
Zinc chromates, as Cr 6.7A	[13530-65-9] [11103-86-9] [37300-23-5]		0.01		
‡ Zinc oxide fume Dust	[1314-13-2]		3(r) 10(r)		10
Zirconium and compounds, as Zr	[7440-67-7]		5		10

‡ BEI for this substance currently under review

TABLE 5: Workplace exposure standards

Part Two

BIOLOGICAL EXPOSURE INDICES

3.0 Biological exposure indices (BEI)

IN THIS SECTION:

3.1 Introduction

3.2 Exposure periods

3.3 Effectiveness

3.4 Biological assays

3.5 Legal requirements

3.6 Issues with biological monitoring

3.7 Information prior to monitoring

3.8 Sample collection

3.9 Interpretation of results

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 (eg 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 (eg 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. Lauwreys, 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 Lead biological exposure indices

IN THIS SECTION:

4.1 Blood lead levels

The following are the BEI for lead in the blood.

4.1 Blood lead levels

The BEI for lead in blood are:

- a BEI of 20μg/dL (0.97μmol/L) of whole blood
- a suspension (removal) level of 30μg/dL (1.45μmol/L) of whole blood for females not of reproductive capacity, and males
- a suspension (removal) level of 10μg/dL (0.48μmol/L) of whole blood for females of reproductive capacity, and those pregnant and/or breastfeeding.

Ideally pregnant 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.

5.0 BEI values

IN THIS SECTION:

5.1 Table of BEI values

5.1 BEIs under review

BEIs for the following substances are currently under review:

- cadmium.

5.2 Table of BEI values

The following table (Table 6) lists the BEI values set by WorkSafe.

EXPOSURE	DETERMINANT	SAMPLING TIME	BEI
Acetone	Acetone in urine	End of shift	50mg/litre
Arsenic	Sum of inorganic arsenic and its methylated metabolites in urine	End of work week. Dietary sources of arsenic should be considered in the sampling protocol	35µg/litre
Benzene	S-Phenylmercapturic acid (S-PMA) in urine	End of shift	25µg/g creatinine
Cadmium	Cadmium in blood Cadmium in urine	Not critical Not critical	0.044µmol/litre (5µg/litre) 5µmol/mol creatinine (5µg/g creatinine)
Carbon disulphide	2-Thioxothiazolidine-4-carboxylic acid (TTCA) in urine	End of shift	0.5mg/g creatinine
Carbon monoxide	Carboxyhaemoglobin in blood	End of shift	3.5% of haemoglobin
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
Chromium (VI) water-soluble fume	Total chromium in urine	End of shift at end of work week End of 8-hour exposure	25µg/litre Increase of 10µg/litre
Cobalt	Cobalt in urine	End of shift at end of work week	15µg/litre
2-Ethoxyethanol and 2-Ethoxyethyl acetate	2-ethoxyacetic acid in urine	End of shift at end of work week	100mg/g creatinine
Ethyl benzene	Sum of mandelic acid and phenylglyoxylic acids in urine	End of shift or end of exposure	0.25g/g creatinine
Fluorides	Fluoride in urine	Prior to shift End of shift	2mg/litre 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		
n-Hexane	2,5-hexanedione in urine	End of shift	5mg/litre
Lead (inorganic)	Lead in blood	Not critical	See section 4 on lead biological exposure indices
Mercury	Mercury in urine	Prior to shift	20µg/g creatinine

EXPOSURE	DETERMINANT	SAMPLING TIME	BEI
Methyl alcohol	Methyl alcohol in urine	End of shift	15mg/litre
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
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
Methyl isobutyl ketone (MIBK)	MIBK in urine	End of shift	0.7mg/litre
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
Phenol	Phenol in urine (following hydrolysis)	End of shift	120mg/g creatinine
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
Styrene	Styrene in urine	End of shift	40µg/litre
Tetrahydrofuran (THF)	THF in urine	End of exposure or shift (within 1 hour of end of exposure)	2mg/g creatinine
Toluene	Toluene in urine o-Cresol in urine (following hydrolysis)	End of exposure or end of shift End of exposure or end of shift	0.03mg/litre 0.3mg/g creatinine
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
Trichloroethylene (TCE)	Trichloroacetic acid in urine	End of shift at end of work week	15mg/litre
Xylene	Methylhippuric acid in urine	End of shift	1.5g/litre

TABLE 6: Biological exposure indices

Appendices

IN THIS SECTION:

Appendix 1: Glossary

Appendix 1: Glossary

TERM	DEFINITION
6.7A carcinogen	Known or presumed human carcinogen.
6.7B carcinogen	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 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, eg 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 (eg condensation of volatilised solids, or incomplete combustion) or chemical processes (eg 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 (eg argon) but more usually comprise molecules, containing more than one atom of one or more elements (eg 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.
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.

TERM	DEFINITION
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 alvelolar 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, ie 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 (eg 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.
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.

TERM	DEFINITION
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 300 mm 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.

Disclaimer

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Work Instruction 12

Aluminium Phosphide Fumigation in containers/chambers other than log vessels

Mandatory Task	Mandatory Process
A: Administration	**Responsible: Ops Admin, supervisor and technician**
1 Take a booking.	Generate a job number by completing a client booking request on-line with the following details: • Client and fumigation site • Contact details • Product or item to be fumigated • Unique identifier (if not given, technician to confirm as per B5) • MPI reference official treatment • Requested date and time of fumigation • Estimated volume of product/consignment/container/chamber
2 Advise of pending fumigation.	Email IVS, port and/or client of pending fumigation with a Notice of Intended Fumigation. **Note:** IVS determines when a fumigation/treatment will be audited.
B: Arriving at the job	**Responsible: Technician**
1 Adhere to the site safety rules.	Follow site rules such as: sign in, present port ID, attend a site induction etc. Follow signage and safety rules.
2 Confirm the premise is suitable for fumigation	If it is a new site, complete a site evaluation form, F9. If the site is not suitable advise the client and Ops Admin and await instructions.

3 Confirm that the product is compatible with Aluminium Phosphide	Some metals (copper, brass, copper alloys, metallic salts and photographic materials) are **not** compatible with phosphine gas. It will also harm precious metals, gold, silver etc. If any of these are present, do not proceed and contact the client to get a waiver of responsibility
4 Determine that the gas will contact the targeted product.	Check the description of the packaging on the job sheet under 'Job description' and 'Comments' for details of packaging. Check for packaging and make sure there is a point of entry for the gas. Plastic covers, foil, coated paper or non perforated polystyrene boxes may not allow gas entry. If gas cannot enter the packaging, the following applies: <u>Open</u> the packaging (at least one side). <u>Remove</u> the packaging or remove the lids from non-perforated polystyrene boxes <u>Perforate</u> the packaging up to 4 perforations of 6mm diameter per $10cm^2$ or 5 perforations of 5mm diameter per $10cm^2$ or numerous pinholes > 6 pinholes per cm^2. If this cannot be achieved, do not fumigate and advise the facility personnel and the treatment supervisor. If the state of the packaging cannot be determined: **For export:** Request the client or freight operator to unpack the product for checking. For export to Australia, refer to : http://www.daff.gov.au/aqis/import/timber/low-risk/wrapping. Alternatively a written 'Declaration of Attesting' can be obtained from the client attesting the state of the packaging. Any written MPI directives or Declaration of Attesting is held with the job sheet file. **For import:** Advise the client to request a BACC to have the goods unpacked at a transitional facility for checking the packaging to be able to fumigate the contents as is.
5 Ensure access to the entire container.	Check that there is space to walk around the outside of the entire container.

	Check the container is not stacked or touching other containers.
C: Setting up and Application	**Responsible: Technician**
1. Confirm the amount of aluminium phosphide required	**Use Aluminium or magnesium phosphide tablets which produce 0.334g for each gram of tablets. Three gram tablets produce 1.0 gms of phosphine. Small (.6gms) tablets produce .2gms Phosphine gas.** Check you have enough for the job. Prepare the correct amount of aluminum phosphide as specified on the job sheet. Check the pallets are within their use-by date and do not use if they are. Calculate the amount required by multiplying the dose rate by the size of the container/consignment. e.g. rate is 2gms, container size is 76.4m3 (High 40 foot container) 2 x 76.4 = 152.8 gms, round up to 153. One Genfume pallet (e.g.) which weighs 3gms will produce 1 gm of phosphine gas. 153 grams of PH3 gas is required so 153 tablets (which weigh 459 gms) are required. Think of each 3gm tablet producing 1gm of phosphine and the calculation is much easier: OR Consignment size: 33.2 Dose rate specified is 2gms / m3 Volume of PH3 required 67gms Each Genfume tablet weighs 3gms and will produce 1.0gms of PH3 gas Number of pallets required is 67 (67 x 3gms = 201gms X .334 = 67) **Table below is for 3gm pallets** **Table shows the number of pallets required to gain either a 2gm or 3gm treatment level across typical container sizes.**
2. Ensure measuring and monitoring equipment is calibrated	Confirm the phosphine monitors have a label showing next calibration due. If calibration is overdue, do not use and request one that is within date.

Volume m3	Rate 2gms/m3	Rate 3gms/m3
10m3	20	30
28.1m3	57	85
33.2m3	67	97
76.4m3	153	230

3 Check the container and apply the pallets	If the container has a seal on it, cut that off with bolt cutters and place it inside the container, do not leave the seal on the ground as they can puncture tyres. Check the container for holes and seal with tape or silicon. Check the roof either from the inside looking for light piercing the darkness or by walking around the container with a mirror fixed to a stick long enough to show you the state of the roof surface. Check the container door seals to make sure the rubber seals are intact. If perished, pre-tape or silicon the seal before shutting the door. Check there is adequate airspace on the top of the container to allow air flow. If not, determine by observation that there is inter-commodity air space which can compensate (allow 20% airspace). For refrigerated containers, check plugs are in the drain at both inside front and rear bottom corners and shut air vents at the back of the container. If not, tape or plug these drains. Tape all the container vents on the outside. Place a calibrated thermometer in the container to record temperature. Phosphine has a boiling point 88 degs below zero however phosphine is more effective at higher temperatures because insect respiration rates increase with temperature. If an importing country's phytosanitary requirement (ICPR) states a minimum temperature, dose rate and fumigation time these must be adhered to. If not using a calibrated electronic monitor, place a Dosimeter Tube inside the chamber and snap off the top. Place it in the air-space, not touching the pallets. Make sure the use-by date is after the end date for the fumigation. Enter the container and decide where to place the tray of pallets. Use a non-combustible (e.g. metal) tray. Best place is on a flat surface, within reach of the doors and in the top half of the space. After placing the tray,

	wearing correct PPE gear including a full face mask with the correct filter, open a flask of pallets and count out the correct number onto the tray. Spread them out, don't make a pile of them. Replace the cap on the flask immediately and close tight. Carry out this procedure as the last thing you do before closing the container door. Apply a lock to the door and a sign with details of the product used, date and time started and the venting date and time. The technician's signature must also be on this sign.
4 Check for leaks	Wait at least 8 hours for the gas to form and return to the container and using a PH_3 monitor such as a Gastec check for leaks. Use tape or sealant to block any leaks you find. Re-check but any leaks below 2ppm are acceptable.
5 Pack up.	Pack up all equipment and check all signage is in place. Complete all the relevant details on the job sheet • Date of fumigation • Time of fumigation • Place of fumigation • Name of the technician fumigating
6. Care with clothing etc	It is easy for a pallet to lodge in an overalls pocket and this will begin to act so ensure overalls are shaken and brushed down or better still washed after each fumigation. Gloves may also be covered in dust which will create a health hazard if left unwashed in a confined space such as the ute of a cab. Shower soon after you complete work to remove all dust traces from skin and hair.
D: Venting	**Responsible: Technician**
1. Check consignment	Make sure the container is where you left it, hasn't been damaged or moved and has not had other containers etc placed above it. In the unlikely event that any of these things have occurred, advise ops admin and await instructions. A decision may have to be made to re-fumigate. If so follow Ops Admin instructions.

2. Check gas levels	Once the exposure time has been reached, if a Dosimeter tube has not been used, pierce the door seal with a metal probe and connect that to either a Kitigawa sampling tube or a calibrated electronic meter and draw a sample, to measure the level of gas inside. The fumigation is passed if it reaches >300ppm for a four-day seed treatment: 200ppm for a seven-day seed treatment >100ppm for a 15-day seed treatment On a Dosimeter tube the reading should be above 40 for both treatments.
3. Open the container	Having donned correct PPE with full face mask with a fresh filter attached, Unlock the container and open the door. Gather the residue on the tray and prepare to dispose of it as in 4 below. Retrieve the thermometer and record the minimum temperature. If it is a cold day cup it in the palm of your hand to prevent it reading the air temperature outside the container. Remember to take note of any correction factor and record the correct temperature on the job sheet.
4. Disposal of residue	Fill a bucket with cold water and at least 40mls (half a cup) of detergent and carefully tip the residue dust into the mixture, stir gently and leave in an open space until the slurry renders the PH3 powder inert. It can then be disposed of through a sewer, not a storm-water drain.
5.Action for a failed fumigation	Advise Ops Admin and await their instructions.
6. Action for a successful fumigation	Complete all details on the job sheet and email that through to Ops Admin.
E: Post Fumigation	**Responsible: Technician**

1. Close the container	Once PH3 levels have dropped to below .03ppm close the container doors and place a "Gas Free" sign on the door. Remove any other signs, cones or "keep out" tape which may have been required during venting. Remove all tape etc from vents and doors.
2. Leave the site	Collect all gear and packaging etc and leave the site making sure to follow all the site rules. Follow the correct procedure to scan and email details of the fumigation to Ops Admin who will issue the certificate to the client and free the container either for removal from the site or collection for export.

Work Instruction 4A

Aluminium Phosphide Initial Application - Logs

Note: These tasks are applicable to the initial application of aluminium phosphide to log vessel holds at berth

Section A: Administration before fumigation	**Responsible:** **Customer Service Team, Treatment Supervisor, Technician**
A1. Take a booking.	• Generate a job number by completing a client booking request on-line with the following details: ○ Client and fumigation site ○ Contact details ○ Product or item to be fumigated ○ Unique identifier (if not given, technician to confirm as per Section D2) ○ MPI reference official treatment (identifying minimum temperature, time and dose rate) ○ Requested date and time of fumigation ○ Estimated volume of cargo (JAS or m^3)
A2. Advise of pending fumigation.	• Email IVS, port and/or client a Notice of Intended Fumigation. • Note: IVS determines when a fumigation/treatment will be audited.
A3. Check the vessel profile document	• Check the related vessel profile document in T:\Vessel Profiles and the vessel risk and observation registers in the same location • If there is no profile for this ship, or it is more than 6 months since one was done: ○ Complete a profile on the vessel when it arrives using form IT25 ○ File the completed record in the vessel profiles folder in T:\Vessel Profiles • Manage any issues identified in the vessel profile inspection, risk register and vessel observation register that negatively impact safety or effectiveness of the fumigation
Section B: Arriving onsite	**Responsible: Technician**
B1. Adhere to the port and vessel safety rules.	• Follow port rules such as: sign in, present port ID, attend a site induction etc. • Follow port signage and safety rules. • Follow vessel safety rules. • **No Genera workers are to be on deck when the crew are lashing or ship's cranes are operating. Liaise with the chief officer or ship's master to determine a suitable time to be on deck.** • **Never enter a fully-loaded, closed hold as logs absorb oxygen and the atmosphere is extremely dangerous.**

Section C: Conduct a pre-inspection	**Responsible: Technician**
C1. Organise the pre-inspection.	• If possible, inspect the vessel before top-stow is loaded so hatch seals can be inspected and side scuppers can be sealed. Otherwise inspect when loading is complete. • Record all details on the IT1 document • Where repairs are required to make the vessel suitable for fumigation: • Organise this via the chief officer or master • Document the required repairs on the Statement of Pre-fumigation Notice of Compliance form (IT1) • Confirm repairs have been completed before fumigation and sign this off on the IT1 form • If unsure about any elements of the pre-inspection confirm it with the ship's engineer or chief officer. Note any guidance they provide on the IT1 form • Where required have the Customer Services Team amend the dosage sheet to show what the initial and top-up application access points are at each location, if changed to address safety concerns (such as issues with 1 forward, enclosed manholes) or to enable effective fumigation. Dositubes are to be placed in the manholes, vents or other access points used for top-up. Provide the ITT with the finalised version of the dosage sheet.

C2. Check the suitability of 1 forward	• Check whether 1 forward can be safely accessed and used at initial and in transit:
	  ○ If the manhole is in an enclosed space or room, gas levels are likely to be concentrated and low oxygen levels may be low making it unsafe for the ITT (who does not have SCBA).
	  ○ It may not be possible to safely access 1 forward inside the rail or over a log bridge at initial or in transit.
	• Follow Section C3 if the 1 forward manhole can't be safely accessed or is in an enclosed space or room.

C3. Manage 1 forward if its unsafe	• If 1 forward is safe for initial but not for in-transit activities, do not place any blankets, dositubes or top-up at this location.
	• If 1 forward is not safe for initial or in-transit activities, use 1 aft only.
	• If not using 1 forward creates a high pellet loading at the 1 aft manhole and clumping is likely:
	  ○ Utilise vents or other safe and suitable access points 1 aft to spread the pellet loading at initial and also top-up if required.
	  ○ Ensure the chief officer or ship's master have the vent screens removed, where used.
	  ○ Check with the customer services team but as a guide, the number of flasks applied to a single manhole shouldn't exceed 25 total, from both initial and top-up.
	• Ensure the dosage sheet is amended accordingly if any of the points above apply.

	• The 1 forward area is still to be inspected and made gas tight even if not used for fumigation:
	  ○ Preferably at an earlier port prior to top-stow being loaded.
	  ○ Alternatively, a safe passage is to be made available over the logs, which is to be organised with the chief officer or ship's master if it can't be accessed inside the rail.

C4. Check for enclosed cargo manholes	• Check whether any cargo manholes are enclosed or in a room. Where so the fumigation must be set up so the ITT does not enter this space at any time, as gas levels are likely to be concentrated in this space and oxygen levels may be low. • Vents or other safe and suitable access points at the same end of the hold could be made available instead with dosage sheets amended accordingly. • Ensure the chief officer or ship's master have the vent screens removed so the ITT can apply the top-up where they are used.

C5. Check the condition of the cargo man-holes or other fumigation access points (ie vents)	• Check the condition all cargo hatch manholes and other fumigation access points (vents, cement ports etc) to ensure as applicable:
	  ○ They have good seals, good fixing screws, nuts and that hinges work well.
	  ○ The hold number and position (such as 2 Fwd) is readable on the manhole somewhere. If it has been recently painted over use a felt tip pen to identify it.
	  ○ Wheel-operated manhole lids are likely to be stiff and may function poorly. Seek assurance that they will at least be greased and can form a good seal.
	  ○ Where required use tape and glue to make the manhole or other fumigation access point gas tight
	• Check for dog-legs in the manholes and decide if piping will be required to by-pass the platform below.

C6. Check the condition of the centre pontoons (if present)	• If there are centre pontoons present, check that they can be made gas tight. If not, associated holds are not to be fumigated, notify the area manager and customer services team where fumigation is not possible. • Use plastic tubing, tape glue and expanding foam to make centre pontoons gas tight • Work with the ships master and engineer if repairs are required
C7. Identify any non-cargo manholes	• Check to see if there are other manholes which could be confused for cargo manholes • They are frequently found on Chinese-built ships for the duct keel, void spaces, or emergency fire pump rooms. • These must be identified and if they are not labelled, do so with a felt pen and add the words "Do not Fumigate".
C8. Check the top-up storage locations	• Open sheds to ensure they are suitable for storing top-up. • Note what other ventilation systems are on the vessel as there may be open vents inside these sheds. • Close tight all vents which can be easily reached. (During loading, hatch vents will usually be out of reach).

C9. Identify and secure leak sources	• Inspect ship holds for gas tightness to ensure there are good seals on hatch covers. • Ensure natural and mechanical vents that lead into the holds are closed and gas tight. Have repairs made where necessary by the ships crew. • Seal all scuppers and drains (if they will be accessible later, this may be done when applying the aluminium phosphide). • Check hold three for any purging valves. They should be closed and sealed and are more likely to be found on Japanese-built vessels.

C10. Secure the accommodation block	• Look to see whether the CO2 system on the vessel goes to the holds. If present confirm it is disabled to avoid gas travelling back to the CO2 room.
	• Inspect external watertight accommodation doors to ensure that these can be closed while the fumigation is in progress.
	• Find the air-conditioning intake. It can be anywhere from the upper deck to the top deck but on most vessels it is on "A" deck. If the intake is on the:
	    ○ Upper deck or A deck it must be closed.
	    ○ Bridge level it could be left open, but must be closed when venting until levels are safe

C11. Finalise the pre-inspection and brief the Master	• Complete pages 1-4 of Form IT1 with either the chief officer or ship's master. • Present this form (IT1) to the ship's master and request him to sign and stamp each page with the ship's stamp and make a copy of each page for you. Only proceed when the ship's master signs and stamps all pages. • Obtain a copy of the ship's particulars. • Leave the vessel pack with the ship's master which includes safety data sheets, IT1 form and a copy of the In-Transit Phosphine Fumigation of Ship's Cargo (Form IT2). • Explain the content of the vessel pack to the ships master and check that they understand, especially the safety information. • If not already known, for the benefit of the in-transit fumigator, ascertain the ship's policy regarding alcohol on board and the daily cost for food and as some ships now have limited WIFI available at sea ask if that is also an option. Make sure that the in-transit fumigator will have acceptable accommodation on board, advise the area manager where not.
Section D: Fumigation preparation	**Responsible: Technician**
D1. Advise of pending fumigation and check the paperwork.	• The technician at the fumigating port is to check a pre-inspection has been completed and if so review the report and ensure any identified actions have been resolved. If a pre-inspection has not yet been completed, the technician is to conduct and document one prior fumigating, as per Section C.

<table>
<tr><td></td><td>Double check and ensure potential leak sources have been secured and natural and mechanical vents are closed and gas tight. If repairs are necessary, organise this with the crew and confirm it has been completed and now gas tight.
Advise the ship’s master that the fumigation team cannot be on deck during crane operation or lashing and make a plan with them around the timing.
Reconcile the IT3 A,B or C with documentation such as vessel stow plan. If it does not match, revert to stevedore, exporter and supercargo to reconcile the stow plan.
If there are void spaces connected to the holds:
Ensure the dosage calculation includes the void space volume (which is on the vessel profile document) and the void space volume is entered into the IT1 document: statement for vessel’s suitability for compliance.
If the void space volume is missing from the vessel profile document, measure then enter the information onto the document then save a copy at T:\Vessel Profiles
Where required have the Customer Services Team update the dosage sheet to account for any void spaces and obtain an amended copy.
Check the hold volumes as per the vessel particulars against the figures on the dosage sheet (Forms IT3 A, B or C), also check the dosages, times and quantity of aluminium phosphine are correct. If there is an error or discrepancy:
Advise the area manager or customer service team who calculated the quantities of aluminium phosphide recalculate the number of flasks or blankets required.
Record this on page 3 of Form IT1 and initial and date any changes.</td></tr>
<tr><td>D2. Confirm the product to be fumigated</td><td>Confirm that all holds to be fumigated contain logs. If it’s a mixed-cargo vessel:
Ensure the other cargo will not be affected by the gas.
Seek a waiver from the cargo owner if necessary. Do not fumigate until you are in receipt of this as phosphine may damage other cargo.</td></tr>
<tr><td>D3. Ensure there is access to the fumigation area.</td><td>Once loading is complete, confirm there is unrestricted access to all manhole covers.
Request the stevedore / ship’s master remove any obstructions. If it cannot be removed, (such as a fallen log on top of the manhole):
Do not proceed and ask either the ship’s master / chief officer to organise for its removal.
Once done, re-check the gas-tightness of the manhole and where required use adhesive and tape to make it gas tight.</td></tr>
</table>

D4. Prepare the fumigant	• Prepare the correct amount of aluminum phosphide as specified on Form IT3.
	• Place flasks in boxes and seal all boxes with tape.
	• Write the following on each box holding flasks:
	    ○ The hold position and number e.g. 2 Aft, 2 Fwd
	    ○ The number of flasks or blankets
	    ○ The application step i.e. initial or top-up
	    ○ If more than one box is required for a particular manhole write 1 of 2 boxes, 2 of 2 boxes etc.
	• Determine the number of hessian sacks required (allow 1 sack per 3 blankets, normally four sacks at each crane tower and two for one forward).
	• Organise enough twine for tying blankets or have these pre-cut to length. If moving the product to the ship, ensure no boxes or drums are left behind. Do a visual count and reconcile this with the IT3 document.

D5. Prepare the dosimeter tubes (dositubes)	• Get 2 dositubes and magnetic clamps per manhole cover • Both are to be placed in the manhole but only one reading is required the other is a backup in case one falls in the hold or fails in transit. • Have at least 3 additional dositubes and magnetic clamps as a backup during initial in case of breakage. • Confirm the dositubes have an expiry date which is at least 21 days later than the ETA to destination port. If not, do not use and request replacements. The expiry date is on each box, record the earliest expiry date on the vessel handover notice (IT5).
D5. Ensure the monitoring equipment is calibrated.	• Confirm the phosphine monitors have a label showing next calibration due. • This should be later than the ETA to destination port. • If calibration is overdue, do not use and request one that is within date
D6. Secure the top-up.	• Store the pre-marked top-up boxes/drums/hessian sacks in the crane tower or deck-shed near to the manhole. Carefully count these onto the ship by reference to the "dosage sheet" form IT3 A, B or C • Double check and ensure the correct number of flasks are in each box • Store these securely (so they will not fall or roll) in a dry area such as a deck shed or a crane tower. • Place them on a shelf where they will stay dry even if water enters the shed. • Ensure the ITT knows where the top-up is stored.

	• Close the door securely before leaving the area.

D7. Identify holds via manhole covers.	• Identify the manhole cover for the hold via the identifying mark on the cover.
	• Ensure you do not confuse a cargo hatch manhole with a duct keel or other manhole as these are sometimes side by side and are not to be fumigated. Check the vessel profile document IT25 if unsure or check with the chief officer or engineer.
	• If a manhole is not marked (forward or aft), look into the hold and determine the direction the logs are running:
	  o If running to aft, this is a forward manhole cover
	  o If running to 'fwd', this is an aft manhole cover.
	  o If the logs are not visible seek this information from the chief officer or engineer.
	  o Using a felt-tip pen write the hold number and location on the manhole to assist the in-transit technician to complete the top-up process later, i.e. 4AFT.

Section F: Initial application via cargo manholes or vents	**Responsible: Technician**
F1. Large Blanket Application (3.4kg)	• Working beside the correct manhole, open the sealed drums and remove the blankets from the foil bags. • Secure twine to the top 200mm of each blanket first then drape these as far down as possible into the manhole and tie them to the manhole securing lugs or ladder, not to the lid. This allows for simple retrieval of the blankets at the end of the fumigation. • Hang blankets separately from different sides of the manhole and try to avoid them touching each other when hanging (this inhibits phosphine gas release) • Tie the blankets in half and "horseshoe" them where required if this helps maintain separation between the blankets. • If possible drape them through the slots on the ladder platforms. • If protruding logs or the platform does not allow blankets to hang through, tie the blankets in half and so "horseshoe" them to expose them to air as much as possible. • Do not allow blankets to crumple onto a platform as this will inhibit fumigant release and create a possible fire hazard.
F2. Small Blanket Application (1.7kg)	• Using the eyelets, join two together with a short piece of twine and tie the top one as for the large blankets above. • Drape these down through the grill. • If there is no grill, hang them separately or horseshoe them if necessary. • Different manhole configurations will dictate how blankets, big or small, will be draped.
F3. Flask Application	• Direct the top of the flask away from you then open the cap

	• Sprinkle pellets into the hold after the blankets have been hung. • Do not allow pellets to cluster on solid surfaces. • As you empty them, shake all the residue out of each flask • See section F4 if there are dog-legs
F4. By passing dog-legs when applying pellets	• Use a PVC pipe or a length of flexible water tubing to sprinkle the pellets into the hold and ensure bypass of the dog-leg. • Do not allow any pellets to cluster on a flat surface. • When fumigating through flexible hose pipe, ensure pellets flow easily which may require shaking of the pipe as pellets are inserted. Listen to hear the clatter in the hold to be sure they are falling through correctly. • Note: The above may have to be carried out with SCBA if entering the manhole. As this will not be an option for the in-transit fumigator, ensure some ducting system set in place will make top-up easy to apply. • To by-pass dog-legs longer than 3m use two 3m PVC pipes joined together to reach the hold opening (the slope from manhole to opening is usually too gradual for nova-flow pipe). • At pre-inspection, it may be necessary to install a flexible hose or PVC pipe from the ladder down through a long dog-leg and into the hold opening to complete the initial dosage and ensure that top-up can be done in-transit. These should be fixed in place with tape or twine. Do not enter the manhole.

F5. Placing dosimeter tubes (dositubes)	• Ensure the end of each tube is broken at the red line.
	• Affix a tag to each tube and write on it which manhole it is for:
	  ○ Make sure the tag or tape does not cover the part of the tube which must be read.
	  ○ Write neatly as the dositubes must be photographed at the end of the job by the ITT.
	• Securely fix two dositubes inside each manhole used for top-up with separate magnetic clamp devices:
	  ○ Place them in a location where the ITT can easily and safely access them, do not use the underside of the lid as they could be dislodged if the hatch is dropped.
	  ○ Space them apart, so if one falls or is knocked the other is not likely to be affected. Only one set of readings is required, two dositubes are placed at each location in case one fails, falls in the hold or gets damaged so we still get a reading.
	  ○ Dositube pairs must be placed forward and aft at each hold. The only exception is 1 forward if it's not safe to access.
	  ○ Keep them as far away from the blankets as possible, at least 0.5 metres. Move the blankets if required ensuring they do not bunch.

	○ Make sure the surface is not rusty or greasy which might prevent the magnets from fixing to the steel. ○ Ensure the open end of the dositubes are horizontal or above (to prevent the contents being lost). • If manholes are not being used, place dositubes where they will be exposed to gas which is likely to be in the alternative openings used for top-up (see section H4). • The CSL holder in charge must ensure the ITT is aware of where they have been placed so he can check levels at top-up and venting.
Section G: Initial application via the main hatches (when it's an option)	**Responsible: Technician**
G1. Prepare to apply the fumigant	• Confirm with the stevedores that the vessel has completed loading and all heavy machinery has been lifted off the top-stow, do not proceed without this confirmation. • Seal all drains / scuppers / vents. • Open the manhole covers. • Where these are available, place mobile lights from the crane house over the manhole to illuminate the hold. Alternatively use head lamps or torches. • Wear PPE gear as specified in the Genera SOP. (Overalls, gloves, hard-hat, safety footwear, full-face mask with a new A2B2 P3 filter) • The mask and filter must be worn at all times when the fumigant packaging is open or being opened, during application plus after hatches and vents are closed and at any other time if the phosphine monitor returns readings of 0.3ppm or higher • Arrange for the hatch covers to be opened via the ship's master or chief officer.
G2. Take the fumigant to the hatches	• Identify boxes / drums with the word 'Initial' on them and bring these to the allocated hatch: • As there will be many boxes, ensure they are numbered one of three, two of three etc. • Do not miss any and so under-fumigate the hold. • Ensure you keep top-up separate which will be numbered as for option one with aft and forward written on the boxes.
G3. Apply the dositubes and blankets	• Wear PPE as specified in the Genera SOP. • Place dositubes and blankets as per section F • Do not apply blankets to manhole 5 AFT, unless otherwise directed on the dosage sheet. 5 aft typically doesn't have space to hang blankets above the logs without them bunching together. • The CSL must double check the dositubes and blankets as per section I1 • Close manhole accesses applicable to the hold.

	• Ensure ventilation covers are tightened and sealed.
G4. Apply the pellets	• Open the flasks and wearing full PPE gear plus boot spikes walk over the logs and sprinkle pellets on top of the logs as evenly as possible. • Avoid gaps in the loading which may hide crevasse-like holes which descend deep into the hold. • Once all aluminium phosphide pellets have been applied, request the hatch covers be closed immediately.
G5. Finalise the initial fumigation	• Check again that all initial product has been applied. • Remove all empty flasks / drums and other rubbish from the vessel. • Top-up will be done using the manholes as for a logs-on-top vessel. Set aside top-up product in crane sheds or deck sheds • Ensure all manholes are shut tight and place "Danger" signs on them.
Section H: Management of 1 forward & challenging / unsuitable manholes	**Responsible: Technician**
H1. Application at 1 forward	• The decision on how best to use one forward will have been made at pre-inspection and be noted on the ship profile document, IT25. See section C2. • If possible and safe for the ITT to recover them, use both one forward and one aft manhole openings for blankets. • When using 1 forward, double check the inner hatch is open. If not it will need opening prior by a team in SCBA • If the manhole is on top of the forecastle, there will usually be a dog-leg and it may be impossible to by-pass it. If so and provided its safe for the ITT to access place the blankets inside (no pellets), attach a dositube which is to be checked at top-up and ventilation, glue a danger sign to it and seal it up . If not safe for the ITT to access do not put blankets or a dositube at this location. • If the manhole is on the deck it may be used for both pellets and blankets if it opens straight into the hold below. • Place all top-up at the number one crane tower with instructions to the in-transit technician to divide this between one aft and one forward if weather and ship layout permits, otherwise it will all be placed in one aft at top-up. • Whilst it is desirable to place pellets in both manholes, the decision to do so will have to be determined on a case-by-case basis with in-transit and initial technician safety as paramount, see section H2 below if 1 forward is not safe to use.
H2. Management of 1 forward if unsafe	• If 1 forward is not safe to use (as per section C2), apply the 1 forward dosage to 1 aft. • If this creates a high pellet loading at the 1 aft manhole and clumping is likely: o Split the pellet dosage between the 1 aft manhole and vents or other safe and suitable access points.

	◦ Ensure the customer service team have updated the dosage sheet to reflect this for initial and top-up as required, have it amended where not. ◦ Have the chief officer or ship's master remove the screens / grates from the vents prior to initial fumigation. ◦ Seal the vents up post application (as per the manholes). ◦ Check with the customer services team but as a guide, the number of flasks applied to a single manhole shouldn't exceed 25 total, from both initial and top-up. • No blankets, dositubes or top-up is to be placed at 1 forward if it's not safe for the ITT to access. • Advise the ITT that 1 forward is not being utilised and that top-up is to be applied via the 1 aft manhole, vents or other access points as applicable.
H3. Management of difficult manhole configurations.	• The goal is to split the fumigation product evenly fore and aft in each hold. Sometimes very long dog-legs, bad access (one forward) or manholes with restricted air-flow into the holds make this difficult to achieve. • Whatever alternative is used, it must not put staff at any greater risk than when applied in the normal way via the manholes. It is important that any alternative to the manholes also allows top-up to be applied easily and safely whilst at sea. • An alternative IT3 which details how the fumigant is to be spread on these vessels, will be provided by the customer service team. • Where a vessel has holds with uneven air-flow access from the manholes it will be necessary to put more product in the better manhole but keep the distribution as even as possible. For example blankets in the restricted manhole and blankets and pellets in the better one.
H4. Alternative options where manholes can't be used	• On some vessels, the manholes may be enclosed or in a room so unsafe for the ITT or have doglegs too long to bypass using pipes or may be enclosed by a solid bulkhead that doesn't allow gas to move freely into the holds. • On such vessels fumigant will have to be applied via other hold openings. This may include natural vents, hatch vents, cement access ports and may even require the dismantling and removal of mechanical venting machinery to provide good access to the holds below. • Wherever possible, ensure fumigant can be applied fore and aft in the holds to create an even spread of fumigant using more than one opening or access point. • All fumigant access points must be safe for the ITT to access and use, plus capable of being made gas-tight once closed.
Section I: Finalising the initial fumigation	**Responsible: Technician**
I1. Final checks	• Before closing the manhole covers or fumigation point (if using vents), the CSL holder in charge of the job must check the following: ◦ Blankets have been hung correctly and are not bunched or crumpled

		○ All dositubes have been correctly labelled, placed, secured, snapped correctly with the open end horizontal or above ○ All flasks of pellets have been evenly applied.
I2.	Secure the man-holes or vents	• Lower and close the manhole gently to ensure blankets or dositubes do not detach, typically a two-person job. If the lid is dropped, open and check that the dositubes and blankets are still in place and secure, fix up any issues. • Tighten each nut of the manhole cover, vent or hatch evenly, avoiding tightening one side too tight at first. • Use spray adhesive and place a danger sign on the manhole cover and any vents or hatches used for fumigation, stating contents are 'Aluminium Phosphide'. Record the fumigation date on the danger sign. • Check hatch vents and scuppers are tightly sealed. • Remove all rubbish, empty flasks and drums from the vessel. • Repeat for each hold.
I3.	Handover to the in-transit technician (ITT).	• Confirm that the in-transit technician (ITT) has at least two calibrated phosphine monitors and sufficient PPE available as per the kit requirement specified on page 4 of the form IT1. • Check that the ITT has three spare dositubes and magnetic clamps. Provide them with some if not. • Confirm the ITT understands the following: ○ The likely top-up date and time. This will be 120 hours + or – 12 hours. ○ Where the top-up is stored ○ How to replace dositubes, if required ○ Where the initial and top-up application access points are on the vessel and that the dosage sheet correctly reflects this (i.e. manholes, vents, cement access ports etc). Where not notify the Customer Services Team who are to send an updated dosage sheet to the ITT. ○ Whether 1 forward will be utilised for top-up or not ○ That within a few hours they must start checking the accommodation area for any gas leaks, especially the engine room. • Get the ITT to sign the Vessel Handover Notice (Form IT5) and the IT3. • Advise the officer on watch that the fumigation is complete. • Ensure the ITT is fully briefed and possesses necessary equipment and documentation to complete the fumigation.

I4. Vessel issues management	• Issues or problems with the vessel that are not resolvable or could be problematic in future (i.e. vents that don't seal properly or issues with leaks that can't be controlled) are to be passed onto the Customer Services Team who are to note the issues and any potential resolutions on the vessel risk or observation registers

SAFE OPERATING PROCEDURES

SOP 10.2 Pre Inspection of a Vessel for a Phosphine Fumigation – Version 5.1

Purpose: **To safely and effectively inspect the vessel to ensure it meets all requirements for a In Hold Phosphine fumigation. To ensure the safety of the vessel's crew and all other workers. The entire operation is to be performed ensuring any hazards are identified and the correct procedures are followed.**

Responsibilities: Line Managers are responsible for ensuring workers have access to this document, receive instruction, training and supervision from a competent person, who signs off the trainee when they have demonstrated competence with this procedure.

All workers on site have a responsibility to ensure this procedure is followed.

All workers have a responsibility to report new hazards or unsafe conditions that are identified.

The Compliance & Safety Team manage and maintain the Safe Operating Procedures with input from workers, Health & Safety Reps and Line Managers.

Review details: Annually before January 2021 or as required following changes. (See back page for review details).

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1. Purpose

To safely and effectively inspect the vessel to ensure it meets all requirements for an In Hold Phosphine fumigation.

Ensuring the safety of the vessel's crew and all other workers.

The entire operation is to be performed ensuring any hazards are identified, any repairs to the vessel are recorded and the correct procedures are followed.

2. Relevant Documents

All operations must be carried out in conjunction with;

- The Control and Safe Use of Fumigants. Pest Management Association of New Zealand Code of Practice.
- Any operating rules issued by the PCBU who manages or controls the site you are operating at.
- Genera Hazard/Risk Register – H32 V23
- Daily toolbox meeting.
- Genera's MPI approved phytosanitary treatment procedures – Work Instruction WA: Aluminium Phosphide Initial Application.
- Aluminium Phosphide Safety Data Sheet
- Workplace Exposure Standards
- International Maritime Dangerous Goods Code
- *Shared Work Area Protocol – Log Yards (Mount Maunganui, Northport & Napier)
- *PFD Water Hazard Policy (Personal Flotation Device)
  *The above two documents are accessible in the Genera Database, Operations Manual, Health and Safety Section https://database.genera.co.nz/admin/manual.asp

3. Personal Protection Equipment (PPE) Required

- Hard Hat.
- Steel Toe Footwear.
- Hi Visibility clothing.
- Gloves.
- Personal Flotation Device (if within 1m of an unguarded waters edge)
- Spikes (for walking on logs)

4. Vehicle Requirements

- Headlights on.
- Flashing Beacon on.
- Raised Vehicle Flags.
- Do NOT have vehicle hazard lights on.

5. Preparation

- Confirm the vessel name and the berth location.
- Notify the ships agent and stevedores of your intention to complete a vessel pre inspection.
- Confirm a suitable date and time for the pre-inspection with the ships agent and stevedores eg when the stevedores are on a smoko break:
    - Ensure there is to be no crane operations or lashing during the pre inspection.
    - If possible, inspect the vessel before the top-stow is loaded so the hatch seals can be inspected and side scuppers can be sealed. Otherwise inspect when loading is complete
- Partially complete all relevant paperwork and photocopy.
- If a stow plan is available check this to the dosage sheet:
    - This is to ensure the holds to be fumigated correspond.
    - If a stowplan is not available confirm the holds to be fumigated with the ships agent.
    - Any variances notify HO – Customer Service Team.
- Check the dosage sheet to the vessel particulars (located on the T/- / Fumigation drive):
    - This is to ensure the hold volumes correspond.
    - Any variances notify HO – Customer Service Team
- Check the Vessel Profile (IT25), Vessel Risk register and Vessel Observation Register (located on the T/- / Fumigation drive):
    - Check the previous notes with any issues or anything unusual with the vessel layout.
    - If there is no profile or the current version is more than 6 months since it was completed, update by completing a new IT25 (after inspection) and save a copy to the 'vessel profile' folder.
    - Manage any issues identified in the vessel profile inspection or risk register or observation register, that negatively impact safety or effectiveness of the fumigation.

5.1 Documentation

- IT1 2x Statement of Pre-Fumigation Notice of Compliance.
- IT2 In Transit Phosphine Fumigation of Ships Cargo.
- IT3/B/C Dosage Sheet, relevant to type of application.
- IT25 Vessel Profile; Suitability for Fumigation
- Vessel Particulars.
- Stowplan.
- SDS – Aluminium Phosphide.
- Pre-Inspection folder.

5.2 Equipment

- Pen.
- Calculator.
- Tape.
- Plastic wrapping or shrink wrap.
- Warning signs.
- PFD's (Personal Floatation device) must be worn when working within one metre of unguarded water's edge. Refer PFD Water Hazard Policy.

6. Vessel Pre-inspection

6.1 On Arrival

- Introduce yourself to the officer at the gangway and advise you are to do a pre-inspection of the vessel as it is to be fumigated.
- Sign the vessel visitor's book.
- Meet with the Captain or CO prior to starting any work to;
  - Make them aware there is to be no crane operations or lashing
  - Arrange a time and communication protocol so you can get off the deck again prior to the crew starting their work.
  - Update Genera of any risks we will be exposed to when conducting our activities and how we mitigate these risks.
  - This update is to be noted in the relevant section of the IT1 form.
  - Update the Genera inspection and fumigation teams and ITT as part of the toolbox before they go on deck.
  - Where there are significant or complex risks identified and not covered in our SOP, complete a JSA or risk assessment before proceeding.
- Check there is to be no crane operations or lashing before you go on deck:
  - If there are any operations (as per above) that start during your pre inspection, all Genera workers are to stop work;
    - Move to a safe location that is not under an active crane or lashing operation.
    - Then move back to the accommodation block or off the vessel when safe to do so.
    - Advise the Captain or CO what happened and do not go back on deck until assurances have been provided that the crew activities will not recommence until you have finished and reported back.
- Be aware of all hazards, underfoot and anything that maybe moving overhead.
- Complete the 'Gas Suitability Statement' IT1 with any vessel officer as per below:

6.2 Scuppers

- Start at hold five:
    - Check the location of the scuppers:
      - If they are at the side of the hold, close them or tape them up now as they will be covered with logs later.
      - If they are at the rear, leave them open to drain and the fumigation crew can close them later.

Drains at the rear, leave for later

Drains at the side, seal up now

6.3 Hatch Covers and Coamings

- With the hatch covers open check the rubber seals which run along the bottom edge of the hatch to ensure the rubber is in good condition with no rubber missing.
- Check the coamings which the rubber sits on for any wear and tear. These must be swept clean by the crew before the hatches are closed.

Coaming must be clear

Rubber seals must be in good condition

6.4 Manholes

- If the manhole is in an enclosed space or room, gas levels are likely to be concentrated and low oxygen levels may be low making it unsafe for the ITT (who does not have SCBA).
- Check all manhole access ways to the vessel holds to ensure:
  - They are not in an enclosed or in a room, as per photos below:

  - If they are, only pellets are to be used for the enclosed space for the initial only with SCBA. (Such as the 'La' type vessels)
  - The ITT is not to access the enclosed space while in transit.

- Vents or other safe and suitable access points at the same end of the hold are to be made available eg cement access ports:
  - If using the cement access ports on each hold;
    - With the CO check the bolts can be loosened and refasten.
    - There must be two cement access ports available per hold; port forward and starboard aft.

- If required, check and or ensure the inner manhole doors (into the hold) are open and remain open. Follow up with the Captain and or CO to arrange for it to be opened prior to the fumigation.
- If using the vents, they need to be as far away from each other as possible to minimize pellet clumping.
- If three or four vents are at each side eg 3 vents at FWD and 3 vents at AFT of the hold, the grills from two vents at AFT and FWD are to be removed
    - Ensure the chief officer or ship's master have at least two vents available, (as per above requirements) prior to the fumigation (initial and top up).

Natural vent with grill on & door open.

Natural vents with grill removed & door open.

- Fumigation is not to proceed until suitable vents are available.
- If the vents or cement access ports are used for the initial and top up, only pellets are to be used.
- Note which access point are being used on the IT1 and update the relevant fumigation and Customer Service Teams.

- All the securing screws are in good condition.
- The rubber seal is in place and is not perished.
- The hinges are not loose.
- Note any repairs that are required onto the IT1 to discuss with the Captain or CO later.

- Where required have the Customer Services Team amend the dosage sheet to show where the fumigation access points are at each location (ie Manholes, vents, cement access ports). This is to be shown for the initial and top up application. Dositubes are to be placed in the manholes, vents or other access points used for top-up.

- Look down the manhole and check that blankets can be hung deep into the hold. This is to ensure they do not pile up at the bottom/not bunched up so when the pellets are applied they land on top of the logs.

6.4.1 Check the Suitability of 1 Forward:

- Check if 1 forward can be safely accessed and used for an initial and top up application.
- It may not be possible to safely access 1 fwd inside the rail or over a log bridge at initial or top up.
- If 1 fwd is safe for the initial but not for in-transit activities, ensure there are no blankets, dositubes or top-up for this location.
- If using 1 forward, check the inner manhole door (into the hold) is open and remains open. Follow up with the Captain and or CO to arrange for it to be opened prior to the fumigation.
- If 1 fwd is **not** safe for the initial or in-transit activities, use 1 aft only.
- If by not using 1 fwd creates a high pellet loading at the 1 aft manhole and clumping is likely:
    - Utilise vents or other safe and suitable access points at 1 aft to spread the pellet loading at initial and also at top-up, if required.
    - Ensure the chief officer or ship's master have the vent screens removed, if to be used.
    - Check with the customer services team but as a guide, the total number of flasks applied to a single manhole shouldn't exceed 25, this is for both the initial and top-up.

- Where required have the Customer Services Team amend the dosage sheet to show where fumigation access points are at each location (ie Manholes, vents, cement access ports). This is to be shown for the initial and top up application. Dositubes are to be placed in the manholes, vents or other access points used for top-up.

- The 1 fwd area is still to be inspected and made gas tight and place a warning sign on it, even if not used for fumigation:
  - Preferably at an earlier port prior to top-stow being loaded.
  - Access via a log bridge or ladder during pre-inspection or prior to fumigation.
  - Alternatively, a safe passage is to be made available over the logs, which is to be organised with the chief officer or ship's master if it can't be accessed inside the rail.

6.4.2 Dog Legs

- Check each manhole for dog legs
  - If they are present, ensure this is written on the IT1.
  - Any manholes with dog legs are to be discussed with the fumigation team preparing the vessel for fumigation.
  - Tubing or a pipe is to be used to assist with spreading the pellets into the hold.

Dog-leg preventing correct pallet fumigation

Nova-flow pipe installed allowing pallet fumigation

6.5 Doors and Vents

- When at 5aft, check for any doors which lead into the accommodation block. These must remain shut during the voyage.
- If there are hold vents on deck, check that they can be sealed/closed.
- If the loading is not too advanced, make a visual check (from the seaward side of the vessel) of the 5aft bulkhead inside the hold.

6.5.1 Vents

- Some Chinese built vessels have large vents inside the storage sheds, as per picture.
- Sealing these is very difficult and the in-transit technician may need to seal the sheds shut and use the crane towers for storage.
- These sheds are then 'out of bounds' during the voyage.
- All external vents to the outside are to be sealed tight.
- Repeat the above procedures at all crane towers.

6.6 Storage Sheds

- As you are moving forward from the seaward side of the vessel, check for any additional side scuppers.
- At 4aft and 5fwd check the storage sheds or crane towers to ensure the 'Top Up' product can be stored there and kept safe and dry.

6.7 Purging Valves

- Check Hold 3 for any purging valves:
  - At either pre-inspection or prior to fumigation these are to be sealed with plastic wrapping and tape.

Large purging valve, only found at hold 3.

- Hold 3 may be filled with water for ballast:
  - Most use the hatch vents to allow the air to escape but a few have special valves for this purpose.
  - As they vent straight to the air, they can easily leak.

6.8 Non-cargo Manholes/2nd Bulkhead/Void Spaces

- Check to see if there are other manholes which could be confused for cargo manholes
- They are frequently found on Chinese-built ships for the duct keel, void spaces, or emergency fire pump rooms.
- These must be identified and if they are not labelled, do so with a felt pen and add the words "Do not Fumigate".
- If there are void spaces connected to the holds eg Da/Chipol & Huanghai type vessels:
  - Ensure the dosage calculation includes the void space volume (which is on the vessel profile document) and the void space volume is entered into the IT1 document 'statement for vessel's suitability for compliance'.
  - If the void space volume is missing from the vessel profile document, measure the space then enter the information onto the document and save a copy to T:\Vessel Profiles
- Where required have the Customer Services Team update the dosage sheet to account for any void spaces and obtain an amended copy.

6.9 Hold One

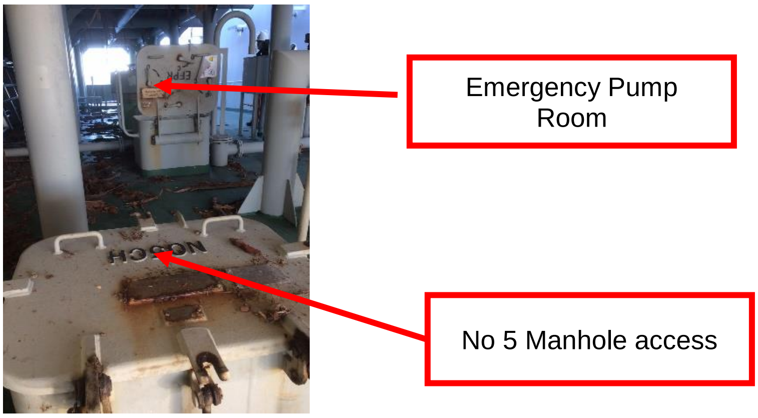
- In addition to the above checks look inside the crane tower for a manhole which leads to the duct keel.
- When discussing the paperwork with the Captain or CO explain that it must be closed during the voyage.
- Check in the bosun's store for a manhole for the duct keel:
    - If it is there close it and place a warning sign on it.
- Check for any other vents or openings which may bring gas from the hold into the store room and note this down on the IT1.

7.0 Final Inspection

- Move down the berth side of the vessel and check if there are any side scuppers to close.
- Be aware of any overhead moving objects.
- Check the engine room for a duct keel.
- Visually check the CO2 room if it has a Smoke Detection Unit, if yes make a note on the IT1.

Smoke Detection Unit in CO2 Room

- Check for any defects in the bulkhead.
- Is there anything unusual with the layout of the vessel eg if it has an emergency fire pump room or a duct keel.



- If there is more than one manhole access in the same area, visually confirm with the CO or crew member which one is to be used and note it on your paperwork.

8.0 Paperwork

- Confirm to the Captain and or CO that you have completed the pre inspection and movement on the deck. The crew are able to continue with crane operations or lashing.
- Ensure the Captain or CO are aware that there will be a fumigation on the vessel.
- Obtain a copy of the vessel particulars and check the hold volumes to the IT1 and IT3 volumes. If this differs on your return to your office notify the Customer Service Team.
- Discuss the fumigation procedure/IT2 with the Captain or CO and hand over a copy to them.
- Discuss and hand over the SDS to the Captain or CO.
- If applicable discuss the repair requirements as per IT1 and agree with the Captain or CO who will do the repairs and when the repairs will be completed.
- Obtain the Captain or CO signature and provide a copy of the IT1in the pre-inspection folder.
- Check with the watch officer, master or chief officer to determine which crew member's are trained in how to safely fit and use a full-face mask and filter, will accompany the ITT on deck for assistance and to help in case of emergency.
- Check that the Captain and or CO understand, especially the safety information.
- Escalate any issues that can't be resolved to the Customer Services Team.
- Keep a copy of the IT1 for our records.
- Check and make a note of the following:
    - The vessel's alcohol policy.
    - What the 'meals on board' cost is for each day.
    - If the ITT will have their own cabin with a bathroom.
    - The nationality of the crew.
- Confirm the date and time of when the loading will be completed and when the fumigation will be started.
- Ensure Genera HO are updated if the vessel has an unusual layout, update the Customer Service Team, your Operations Manager and the division who are to complete the initial application.
- On return to your office update the Customer Service Team and your supervisor or manager with the above.
- Ensure a vessel profile is completed and updated online.
- If the vessel particulars differ scan and email a copy to the Customer Service Team.
- Ensure you receive an updated copy of the IT3.

9.0 Document Review History

Date	Document Name and Version	Reviewer
July 2014	SOP 10.2 Pre Inspection of a Vessel V1.0	Mike Goss
December 2015	SOP 10.2 Pre Inspection of a Vessel V2.0	Mike Goss
March 2017	SOP 10.2 Pre Inspection of a Vessel V3.0	Michelle Pomare
June 2017	SOP 10.2 Pre Inspection of a Vessel V4.0	Michelle/Gavin
December 2018	SOP 10.2 Pre Inspection of a Vessel V5.0	Robert Maassen
January 2020	SOP 10.2 Pre Inspection of a Vessel V5.1	David Baker / Operations Managers / Michelle - Admin

SAFE OPERATING PROCEDURES

SOP 10.4 Phosphine Application to Vessel Holds – Version 10.1

Purpose: **To safely apply the initial application of aluminium phosphide to the log vessel holds. To ensure the safety of the vessel's crew and all other workers. The entire operation is to be performed ensuring any hazards are identified and the correct procedures are followed.**

Responsibilities: Line Managers are responsible for ensuring workers have access to this document, receive instruction, training and supervision from a competent person, who signs off the trainee when they have demonstrated competence with this procedure.

All workers on site have a responsibility to ensure this procedure is followed.

All workers have a responsibility to report new hazards or unsafe conditions that are identified.

The Compliance & Safety Team manage and maintain the Safe Operating Procedures with input from workers, Health & Safety Reps and Line Managers.

Review details: Annually before January 2021 or as required following changes. (See back page for review details).

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1. Purpose

To safely apply the initial application of aluminium phosphide fumigant to the vessel holds. To ensure the safety of the vessel's crew and all other workers. The entire operation is to be performed ensuring any hazards are identified and the correct procedures are followed.

The key to a successful and safe application of the fumigant is to:
- Achieve an even distribution of the fumigant thoughout the vessel holds.
- Crew safety instructions and checks.

2. Relevant Documents

All operations must be carried out in conjunction with;

- The Control and Safe Use of Fumigants. Pest Management Association of New Zealand Code of Practice.
- Any operating rules issued by the PCBU who manages or controls the site you are operating at.
- Genera Hazard/Risk Register – H32 V23
- Daily tool box meeting.
- Genera's MPI approved phytosanitary treatment procedures – Work Instruction 4A: Aluminium Phosphide Initial Application.
- Aluminium Phosphide Safety Data Sheet
- Workplace Exposure Standards
- *International Maritime Dangerous Goods Code Safe Use of Respirators Policy
- *Shared Work Area Protocol – Log Yards (Mount Maunganui, Northport & Napier)
- *PFD Water Hazard Policy (Personal Flotation Device).
  *The above three documents are accessible in the Genera database, Operations Manual, Health and Safety Section https://database.genera.co.nz/admin/manual.asp

3. Personal Protection Equipment (PPE) Required

- Hard Hat.
- Steel Toe Footwear.
- Hi Visibility overalls.
- Gloves.
- Spikes (for walking on logs)
- Personal Flotation Device (if within 1m of an unguarded waters edge)

4. Vehicle Requirements

- Headlights on.
- Flashing Beacon on.
- Raised Vehicle Flags.
- Do NOT have vehicle hazard lights on.

5. Preparation

5.1 Equipment

- Hessian sacks.
- String.
- Warning signs/stickers for manhole lids.
- Current dosi tubes – in a plastic sleeve (yellow end) with string attached.
- Spray glue.
- Tape.
- Head torch.
- Hand torch.
- Silicone or no more gaps or expanding foam.
- Shrink wrap and or plastic.
- PVC pipe or water tubing.
- Knife.
- Pen/permanent marker.
- Forklift.
- Mancage (refer to section 6.3 – Attaching the mancage to the forklift).
- Approved Harness's and Lanyard's.
- 3 Spare dositubes – with an expiry date which is later than the vessel eta into destination port.
- Magnetic clamps for the ITT

5.2 Safety Equipment

- SCBA if required (refer to pre-inspection checklist).
- Full face mask.
- A2B2 P3 Phosphine filters.
- Calibrated phosphine monitors.
- PFD's (Personal Floatation device) must be worn when working within one metre of unguarded water's edge. Refer PFD Water Hazard Policy.

5.3 Documentation

- IT3/3b/3c Dosage Sheet, relevant to the type of application.
- IT4 Fumigation Certificate – Phosphine In Transit Fumigation.
- IT5 Vessel Handover Notice.
- IT20 Port of Napier only – ITT and Pilot Checklist

5.4 Check the Previous Paperwork, Product and Communications

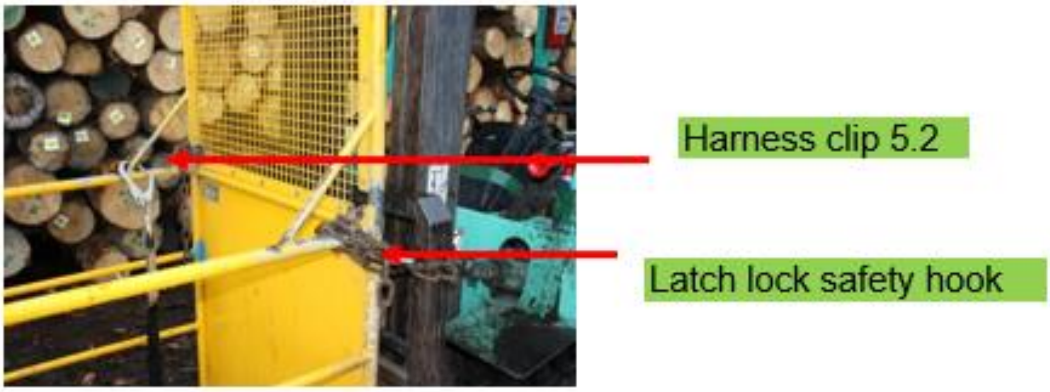
- Pre-inspection paperwork (IT1):
    - Is 1fwd suitable or not.
    - If you are to access any enclosed spaces with SCBA.
    - If you are to access the natural vents or other openings in the hold and at which holds.
    - If there are any manholes that are enclosed or in a room that the ITT will not be able to access
    - Any risks on board the vessel to be aware of.
    - If a pre-inspection has not yet been done, complete one by following SOP 10.2 prior to starting the fumigation.
- Emails
- Check the Vessel Profile (IT25), Vessel Risk register and Vessel Observation Register

(located on the T/- / Fumigation drive) and ensure any issues are checked or
The alternatives are followed.

- Dosage sheet is correct to any changes on the IT1
- If available, check the stowplan to ensure logs have been loaded into all holds and all holds are destined for China and to be fumigated.
- Nothing unusual about the vessel layout eg no additional manholes and no
- Smoke Detection Unit in the CO2 room.
- Ensure you are aware which manholes are to have the fumigant applied to.
- Check and confirm the actual product to the dosage sheet while placing in the vehicle and ensure:
    - To count the number of flasks in each box and it is the correct amount required.
    - Each box of the Initial product is clearly marked with INITIAL (INT) and the manhole ID (ie 1 aft or 2 fwd).
    - Each box of the Top Up product is clearly marked with TOP UP (TU) and the manhole ID (ie 1 aft or 2 fwd).

6. Man Cage

6.1 Attaching to the Forklift



- Attach the man cage to the forklift by inserting the forks into the tunnels under man cage.
- The forklift forks are not to be inserted along the side of the man cage.
- Secure the man cage to the forklift with the latch lock safety hook.
- Proceed to the berth, adhere to a controlled speed and be aware of other vehicles.

6.2 Entering the Man Cage

- Remain in the rear section of the man cage and ensure the gate is closed.
- Signal to the forklift operator that you are ready to be raised.
- Refer section 7.3 – loading the product onto the vessel.

6.3 Forklift Operator

- The forklift operator is to remain seated on the forklift during the entire operation.
- Raise the man cage slowly and smoothly.
- The forklift operator is to continually communicate with the workers in the man cage.
- Any loads or if using the man cage are to be lowered to the ground and the forklift put in neutral prior to anyone approaching or exiting.

6.4 Exiting the Man Cage

- When all product has been loaded onto the vessel, the forklift operator is to lower the man cage slowly and smoothly until it is on the ground.
- The workers are to remain behind the closed gate until the forklift operator has signalled that it is safe to exit.
- The workers are not to travel on the man cage to the next crane house. They must walk and then be lifted.

7. Pre-fumigation

- Check with the stevedores when the vessel will complete loading.
- Confirm with the ships agent the time you will start the application.

7.1 Toolbox meeting

- Brief the Genera workers on the fumigation plan and include:
  - The vessel name and the berth location.
  - The time you will board the vessel and start the application.
  - The weather forecast.
  - The vessel holds to be fumigated, anything unusual about the vessel layout, if the CO2 room has a Smoke Detection Unit.
  - The type of product to be used blankets and pellets or just all pellets.
  - Port of Napier Only – ensure the technician in charge and ITT are to complete the IT20 Pilot Checklist.
  - Any vessel specific hazards detected in the pre-inspection and how to manage them. A JSA is to be completed prior to starting if significant or complex risks are identified which are not covered by the SOP

7.2 Vessel

7.2.1 On Arrival

- PFD's must be worn when working within one metre of unguarded waters edge. **This is mandatorary at Eastland Port, Gisborne and Port Taranaki, New Plymouth.**
- Introduce yourself to the officer at the gangway and advise you are to fumigate the vessel holds.
- Sign the vessel visitor's book.
- Meet with the Captain or CO prior to starting any work to;
  - Make them aware there is to be no crane operations or lashing

    - Arrange a time and communication protocol so you can get off the deck again prior to the crew starting their work.
    - Determine which crew member's are trained in how to safely fit and use a full-face mask and filter, will accompany the ITT on deck for assistance and to help in case of emergency.
- Check there is to be no crane operations or lashing before you go on deck:
    - If there are any operations (as per above) that start during your pre inspection, all Genera workers are to stop work;
        - Move to a safe location that is not under an active crane or lashing how to use a full-face mask and filter.operation.
        - Then move back to the accommodation block or off the vessel when safe to do so.
        - Advise the Captain or CO what happened and do not go back on deck until assurances have been provided that the crew activities will not recommence until you have finished and reported back.
- Be aware of all hazards, underfoot and anything that maybe moving overhead.
- Check the required repairs from the pre-inspection or vessel observation register have been completed.
- Confirm there is access to all manholes and manhole lids, vents or other access points needed for initial and or top-up.
- If the initial and / or top up is via the vents; check at least two vent screens (mesh/grills) at each end of the hold have been removed and at the correct holds.
- Check all holds that are to be fumigated contain logs and there is no mixed cargo:
    - Ensure the other cargo will not be affected by the gas.
    - Seek a waiver from the cargo owner if necessary. Do not fumigate until you are in receipt of this as phosphine may damage other cargo.
- If using 1 forward or the void spaces/2nd bulkhead, check the inner manhole doors (into the holds) are opened. If not it will need opening prior to the fumigation by a team in SCBA.
- Where required have the Customer Services Team amend the dosage sheet to show what the top-up and fumigation access points are at each location if changed to address safety concerns or to enable effective fumigation. Dositubes are to be placed in the manholes, vents or other access points used for top-up. Provide the ITT with the finalised version of the dosage sheet.
- Escalate any issues that can't be resolved to the Customer Services Team.

- If the CO_2 room has a Smoke Detection Unit, ensure it is switched off. This is to remain switched off for the entire the voyage. (There is no oxygen in the holds once the logs have been loaded).

7.2.2 Sealing

- Ensure all natural and mechanical ventilation that lead into the holds are closed and gas tight. Have repairs made where necessary by the ships crew.

- Seal the scuppers Fwd and Aft of each hold with tape, if required.

- Seal any fans with shrink wrap, plastic wrapping, glue or tape, if required

7.2.3 Management of 1 Forward

- 1 fwd is only to be fumigated at initial if it can be safely accessed from inside the rail.
- If 1 fwd can be safely accessed at initial but is in an enclosed space, room or can't be safely accessed inside the rail by the ITT when in transit, then it's to be fumigated at initial only, with no blankets, top-up or dositubes placed at that location.
- If using 1 forward, check the inner manhole doors (into the holds) are opened. If not, it will need opening prior to the fumigation by a team in SCBA.
- Advise the ITT that 1 forward is not being utilised and that top-up is to be applied via the 1 aft manhole, vents or other access points as applicable.
- If unsafe to access:
  - Ensure 1 fwd has been checked and made gas tight prior to the fumigation using a log bridge or ladder if there isn't another means of reaching the area inside the rail.
  - The fumigation team are not to hand over the vessel until the above has been completed.

- As a guide, the number of flasks applied to a single manhole shouldn't exceed 25 in total, for both initial and top-up.
- Apply the 1 forward dosage to 1 aft.
- If this creates a large volume of pellets at the1 aft manhole and clumping is likely:
  - Split the pellet dosage between the 1 aft manhole and vents or other safe and suitable fumigation access points.
  - Have the chief officer or ship's master remove the screens / grates from the vents prior to initial fumigation.
  - Ensure the customer service team have updated the dosage sheet to reflect this for initial and top-up as required, have it amended where not.
- Seal the vents up post application (as per the manholes).

7.2.4 Alternative Options When the Manholes Cannot Be Used

- Where manholes are in a room or enclosed space the fumigation must be set up so the ITT does not enter this space at any time, as gas levels are likely to be concentrated in this space and oxygen levels may be low.
- Also if a manhole has doglegs that are too long to bypass by using pipes or is enclosed by a solid bulkhead that doesn't allow gas to move freely into the holds:
  - The product will then will have to be applied via other hold openings.
  - This may include natural vents, hatch vents, cement access ports and may even require the dismantling and removal of mechanical venting machinery to provide good access to the holds below.
  - Where vents need to be used, have the chief officer or ship's master remove the screens / grates from the vents prior to initial fumigation.
- If using void spaces/2nd bulkhead, check the inner manhole doors (into the holds) are opened. If not, it will need opening prior to the fumigation by a team in SCBA.
- If using the cement access ports, there must be two cement access ports available per hold; port forward and starboard aft.
- Wherever possible, ensure the fumigant can be applied fore and aft in the holds to create an even spread of fumigant using more than one opening or access point.
- All fumigant access points must be safe for the ITT to access and use, plus be capable of being made gas-tight once closed.

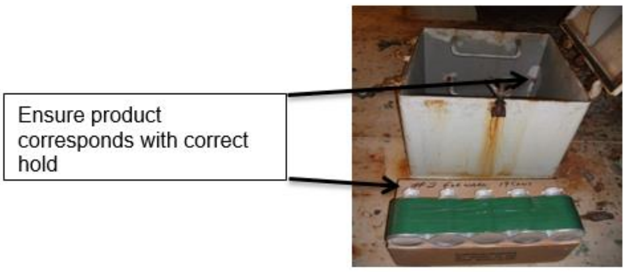
7.3 Loading the product onto the vessel

- Load the prepared product and equipment onto the man cage for the relevant crane housing and confirm it corresponds with the dosage sheet eg number 1 crane housing = 1 aft, 2 fwd initial and top up.
- Ensure the product is secured and will not fall out of the man cage.
- The forklift operator will drive to the relevant crane housing.
- Before being lifted up, ensure the workers who have entered the man cage are in the safe area behind the closed gate.
- The forklift operator must remain seated on the forklift during the entire operation.
- The forklift operator must ensure that there are no passengers on the man cage when travelling up and down the berth. They are to only be lifted up and down to and from the vessel.

- Be aware of slips and trips when moving around the vessel.
- Watch over head for any operations and or movements.
- If lashing, crane or other vessel operations start during your preparation or during application, all Genera workers are to stop work and move to a safe location until the activities have stopped (follow Section 7.2)

- Place the top up application and hessian sacks inside stores or crane housing.
- Ensure the top up product is secured and stored off the floor.

- Place the initial product at the relevant manhole ready for application.
- Ensure the manhole number and the product correspond.
- If the hold number is not present, look into the hold and see what way the logs are running, forward or aft.



8. Application

Always check for phosphine presence with your monitor and wear your mask and A2B2 P3 filter if levels are detected at or above 0.3ppm. Turn the monitor off if levels approach 10ppm to prevent saturation but keep your mask and filter on until you have moved to a location and checked and established with your monitor that phosphine levels are back below 0.3ppm.

Double check and ensure potential leak sources have been secured and natural and mechanical vents are closed and gas tight. If repairs are necessary, organise this with the crew and confirm it has been completed and now gas tight.

8.1 Preparation

- Clearly identify the man hole by observing the manhole ID number on the lid or the side of the manhole.
- Complete a visual inspection e.g. can you see logs inside the hold.
- Complete a smell test e.g. can you smell logs inside the hold.
- If no. Check with the crew members which holds the logs have been loaded into.
- If yes, open the manhole lids and secure it with the locking pin.
- Use a torch if required.

8.2 Dositubes

- Prior to the initial application, securely fix two dositubes inside each fumigation access point and or manhole as per the MPI work instruction 4A.
- If using the cement access ports, remove the bolts and lid, apply the dositubes, then replace the lid and fasten the bolts.
- There must be two cement access ports available per hold; port forward and starboard aft.
- Ensure the ITT is aware of where they have been placed so he is able to complete his checks.

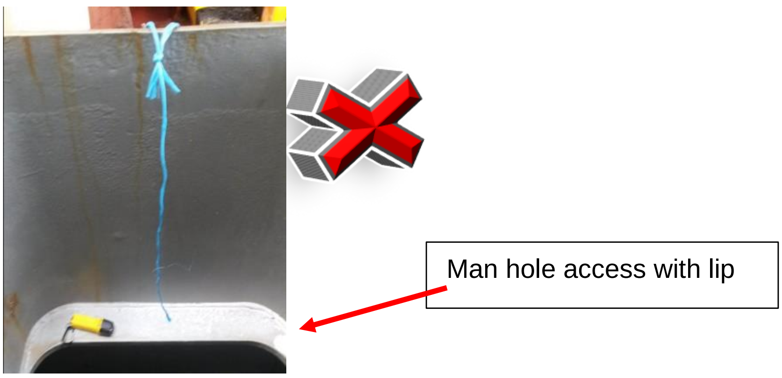
8.3 Application with Blankets

- Most blankets are supplied with six blankets in a drum and generally one drum is for each manhole.
- A mask and filter must be worn at all times when the fumigant packaging is open or being opened, during application plus after hatches and vents are closed and at any other time if the phosphine monitor returns readings of 0.3ppm or higher.

- Use SCBA gear if you are required to enter the hold. Only workers with current SCBA and confined space entry training and certification are permitted to do this, there must be another staff member in SCBA also trained to support the person entering the hold.
- Do not apply blankets to manhole 5 AFT, unless otherwise directed on the dosage sheet.
- Tie a knot in the string so it will loop over the wingnut hinge.
- Tie the blankets in half and "horseshoe" them where required if this helps maintain separation between the blankets.

- Remove the lid from the drum.
- Remove the foil bag from the drum and cut the bag open with a knife.
- Immediately remove the blanket from the foil bag and place on the deck.
- Keep the blanket away from your face.
- If there is smouldering or a fire, roll the blanket out immediately on the deck.

- With the string tie a double knot around the blanket at least 30cm from the end of the blanket.
- Do not tie the string through the eyelet.
- To avoid cutting of the string while in transit, do not tie the string on the side of the man hole access where there is a lip.



- Ensure all blankets are fully unrolled before hanging.
- Place the blankets down the manhole between the grating.
- If the grating is in mesh form, hang the blankets above the grate.
- Attach the string to the secured devices on the manhole.
- Attach the string to the ladder if the manhole has a wheel type securing device.
- DO NOT attach the strings to the manhole lids.


- Tie and hang all blanket's required for this manhole as per the above procedures.


- Place the empty foil bags back into an empty drum with out the lid on, ready for removal from the vessel.
- Proceed to the next manhole and repeat the above procedures.
- If there are no pellets to be applied:
    - Close the manhole lid and ensure the blankets or dositubes do not detach.
    - Tighten each nut of the manhole cover, vent or hatch evenly, avoiding tightening one side too tight at first.

8.4 Application with Pellets

- Put on your full-face mask with a new filter.
- Use SCBA gear if you are required to enter the hold. Only workers with current SCBA and confined space entry training and certification are permitted to do this, there must be another staff member in SCBA also trained to support the person entering the hold.
- Remove the flask from the box.
- Open the flasks with a spanner or flask opener.
- Keep the flask away from your face as flasks can be under pressure and can release gas when opened.
- Sprinkle or pour the pellets into the manhole.
- Distribute the pellets in the man hole area as best as you can.
- Apply all flasks required for this manhole as per the above

procedures.

- Use a PVC pipe or water tubing if the holds have dog legs and ensure the pellets bypass the dog leg.

- Place the empty flasks back into the box without the lids on, ready for removal from the vessel.
- Proceed to the next manhole and repeat the above procedures.

8.5 Securing the Manhole lid

- Remove the safety device and close the manhole lid using both hands.

- Ensure the blankets or dositubes have not detached from the lid.
- Secure the manhole lid with the wing nuts:
    - Do not overtighten.
    - Work around the lid.
    - Keep tightening the nuts until they are all tight.
- Secure a warning sign to the top of the manhole lid, use spray glue if required.
- Write the start time, start date and the total exposure period of 264 hours on the sign.

9. Departure from the Vessel

- Place any rubbish into the drums or boxes and remove from the vessel.
- Ensure all rubbish is removed.
- Ensure all top up product has been checked and secured in the correct location.
- Ensure there are sufficient hessian sacks stored on the vessel.
- Ensure the ITT has signed all relevant paperwork.
- Complete and sign the IT4 and IT5 and handover copies to the captain.
- Update the captain or chief officer that the initial application has been completed.
- Brief the ITT and ensure they understand the top up procedure, where the fumigation access points are for the top-up (manholes, vents, cements ports etc) .
- Check this is reflected on the dosage sheet, have the Customer Services Team update it where required.

- Ensure the ITT has all their safety equipment for their voyage:
    - Two calibrated phosphine monitors.
    - Sufficient PPE and filters
    - Three spare dositubes and magnetic clamps
    - Spikes for walking on logs
- Port of Napier Only – ensure all procedures have been completed by the technician in charge and ITT for the IT20 Pilot Checklist.
- Complete and return all paperwork to HO – Customer Service Team.
- On return to your office/portacom, ensure the empty flasks and lids are triple rinsed, punctured and disposed in a approved landfill/recycling.

10. Document Review History

Date	**Document Name and Version**	**Reviewer**
June 2016	SOP 10.4 Phosphine Application to Vessel Holds V6.0	Mike Goss
March 2017	SOP 10.4 Phosphine Application to Vessel Holds V7.0	Michelle Pomare
June 2017	SOP 10.4 Phosphine Application to Vessel Holds V8.0	Michelle Pomare /Gavin Smales
November 2017	SOP 10.4 Phosphine Application to Vessel Holds V9.0	Gavin – Operations / Michelle - Admin
January 2018	SOP 10.4 Phosphine Application to Vessel Holds V9.1	Michelle - Admin
December 2018	SOP 10.4 Phosphine Application to Vessel Holds V10.0	Robert Maassen
January 2020	SOP 10.4 Phosphine Application to Vessel Holds V10.1	David Baker / Operations Managers / Michelle - Admin

SAFE OPERATING PROCEDURES

SOP 10.4 Phosphine Application to Vessel Holds – Version 10.1

Purpose: **To safely apply the initial application of aluminium phosphide to the log vessel holds. To ensure the safety of the vessel's crew and all other workers. The entire operation is to be performed ensuring any hazards are identified and the correct procedures are followed.**

Responsibilities: Line Managers are responsible for ensuring workers have access to this document, receive instruction, training and supervision from a competent person, who signs off the trainee when they have demonstrated competence with this procedure.

All workers on site have a responsibility to ensure this procedure is followed.

All workers have a responsibility to report new hazards or unsafe conditions that are identified.

The Compliance & Safety Team manage and maintain the Safe Operating Procedures with input from workers, Health & Safety Reps and Line Managers.

Review details: Annually before January 2021 or as required following changes. (See back page for review details).

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1. Purpose

To safely apply the initial application of aluminium phosphide fumigant to the vessel holds. To ensure the safety of the vessel's crew and all other workers. The entire operation is to be performed ensuring any hazards are identified and the correct procedures are followed.

The key to a successful and safe application of the fumigant is to:

- Achieve an even distribution of the fumigant thoughout the vessel holds.
- Crew safety instructions and checks.

2. Relevant Documents

All operations must be carried out in conjunction with;

- The Control and Safe Use of Fumigants. Pest Management Association of New Zealand Code of Practice.
- Any operating rules issued by the PCBU who manages or controls the site you are operating at.
- Genera Hazard/Risk Register – H32 V23
- Daily tool box meeting.
- Genera's MPI approved phytosanitary treatment procedures – Work Instruction 4A: Aluminium Phosphide Initial Application.
- Aluminium Phosphide Safety Data Sheet
- Workplace Exposure Standards
- *International Maritime Dangerous Goods Code Safe Use of Respirators Policy
- *Shared Work Area Protocol – Log Yards (Mount Maunganui, Northport & Napier)
- *PFD Water Hazard Policy (Personal Flotation Device).
  *The above three documents are accessible in the Genera database, Operations Manual, Health and Safety Section https://database.genera.co.nz/admin/manual.asp

3. Personal Protection Equipment (PPE) Required

- Hard Hat.
- Steel Toe Footwear.
- Hi Visibility overalls.
- Gloves.
- Spikes (for walking on logs)
- Personal Flotation Device (if within 1m of an unguarded waters edge)

4. Vehicle Requirements

- Headlights on.
- Flashing Beacon on.
- Raised Vehicle Flags.
- Do NOT have vehicle hazard lights on.

5. Preparation

5.1 Equipment

- Hessian sacks.
- String.
- Warning signs/stickers for manhole lids.
- Current dosi tubes – in a plastic sleeve (yellow end) with string attached.
- Spray glue.
- Tape.
- Head torch.
- Hand torch.
- Silicone or no more gaps or expanding foam.
- Shrink wrap and or plastic.
- PVC pipe or water tubing.
- Knife.
- Pen/permanent marker.
- Forklift.
- Mancage (refer to section 6.3 – Attaching the mancage to the forklift).
- Approved Harness's and Lanyard's.
- 3 Spare dositubes – with an expiry date which is later than the vessel eta into destination port.
- Magnetic clamps for the ITT

5.2 Safety Equipment

- SCBA if required (refer to pre-inspection checklist).
- Full face mask.
- A2B2 P3 Phosphine filters.
- Calibrated phosphine monitors.
- PFD's (Personal Floatation device) must be worn when working within one metre of unguarded water's edge. Refer PFD Water Hazard Policy.

5.3 Documentation

- IT3/3b/3c Dosage Sheet, relevant to the type of application.
- IT4 Fumigation Certificate – Phosphine In Transit Fumigation.
- IT5 Vessel Handover Notice.
- IT20 Port of Napier only – ITT and Pilot Checklist

5.4 Check the Previous Paperwork, Product and Communications

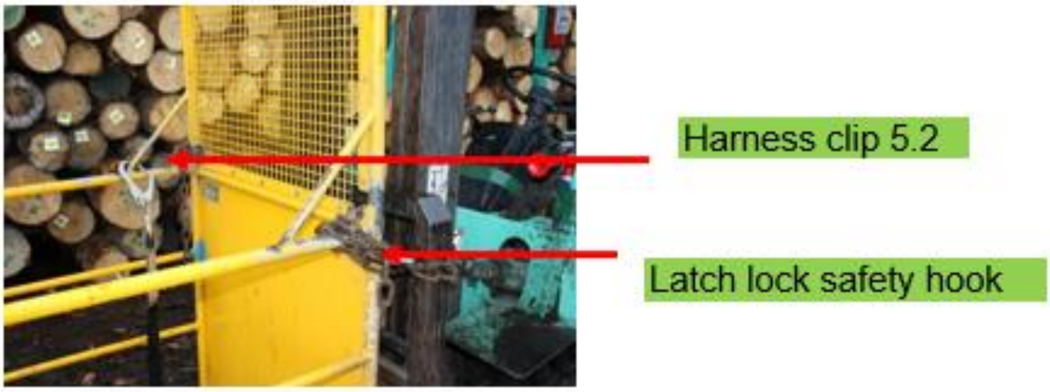
- Pre-inspection paperwork (IT1):
    - Is 1fwd suitable or not.
    - If you are to access any enclosed spaces with SCBA.
    - If you are to access the natural vents or other openings in the hold and at which holds.
    - If there are any manholes that are enclosed or in a room that the ITT will not be able to access
    - Any risks on board the vessel to be aware of.
    - If a pre-inspection has not yet been done, complete one by following SOP 10.2 prior to starting the fumigation.
- Emails
- Check the Vessel Profile (IT25), Vessel Risk register and Vessel Observation Register

(located on the T/- / Fumigation drive) and ensure any issues are checked or The alternatives are followed.

- Dosage sheet is correct to any changes on the IT1
- If available, check the stowplan to ensure logs have been loaded into all holds and all holds are destined for China and to be fumigated.
- Nothing unusual about the vessel layout eg no additional manholes and no
- Smoke Detection Unit in the CO2 room.
- Ensure you are aware which manholes are to have the fumigant applied to.
- Check and confirm the actual product to the dosage sheet while placing in the vehicle and ensure:
  - To count the number of flasks in each box and it is the correct amount required.
  - Each box of the Initial product is clearly marked with INITIAL (INT) and the manhole ID (ie 1 aft or 2 fwd).
  - Each box of the Top Up product is clearly marked with TOP UP (TU) and the manhole ID (ie 1 aft or 2 fwd).

6. Man Cage

6.1 Attaching to the Forklift



- Attach the man cage to the forklift by inserting the forks into the tunnels under man cage.
- The forklift forks are not to be inserted along the side of the man cage.
- Secure the man cage to the forklift with the latch lock safety hook.
- Proceed to the berth, adhere to a controlled speed and be aware of other vehicles.

6.2 Entering the Man Cage

- Remain in the rear section of the man cage and ensure the gate is closed.
- Signal to the forklift operator that you are ready to be raised.
- Refer section 7.3 – loading the product onto the vessel.

6.3 Forklift Operator

- The forklift operator is to remain seated on the forklift during the entire operation.
- Raise the man cage slowly and smoothly.
- The forklift operator is to continually communicate with the workers in the man cage.
- Any loads or if using the man cage are to be lowered to the ground and the forklift put in neutral prior to anyone approaching or exiting.

6.4 Exiting the Man Cage

- When all product has been loaded onto the vessel, the forklift operator is to lower the man cage slowly and smoothly until it is on the ground.
- The workers are to remain behind the closed gate until the forklift operator has signalled that it is safe to exit.
- The workers are not to travel on the man cage to the next crane house. They must walk and then be lifted.

7. Pre-fumigation

- Check with the stevedores when the vessel will complete loading.
- Confirm with the ships agent the time you will start the application.

7.1 Toolbox meeting

- Brief the Genera workers on the fumigation plan and include:
  - The vessel name and the berth location.
  - The time you will board the vessel and start the application.
  - The weather forecast.
  - The vessel holds to be fumigated, anything unusual about the vessel layout, if the CO2 room has a Smoke Detection Unit.
  - The type of product to be used blankets and pellets or just all pellets.
  - Port of Napier Only – ensure the technician in charge and ITT are to complete the IT20 Pilot Checklist.
  - Any vessel specific hazards detected in the pre-inspection and how to manage them. A JSA is to be completed prior to starting if significant or complex risks are identified which are not covered by the SOP

7.2 Vessel

7.2.1 On Arrival

- PFD's must be worn when working within one metre of unguarded waters edge. **This is mandatorary at Eastland Port, Gisborne and Port Taranaki, New Plymouth.**
- Introduce yourself to the officer at the gangway and advise you are to fumigate the vessel holds.
- Sign the vessel visitor's book.
- Meet with the Captain or CO prior to starting any work to;
  - Make them aware there is to be no crane operations or lashing

- Arrange a time and communication protocol so you can get off the deck again prior to the crew starting their work.
    - Determine which crew member's are trained in how to safely fit and use a full-face mask and filter, will accompany the ITT on deck for assistance and to help in case of emergency.
- Check there is to be no crane operations or lashing before you go on deck:
    - If there are any operations (as per above) that start during your pre inspection, all Genera workers are to stop work;
        - Move to a safe location that is not under an active crane or lashing how to use a full-face mask and filter.operation.
        - Then move back to the accommodation block or off the vessel when safe to do so.
        - Advise the Captain or CO what happened and do not go back on deck until assurances have been provided that the crew activities will not recommence until you have finished and reported back.
- Be aware of all hazards, underfoot and anything that maybe moving overhead.
- Check the required repairs from the pre-inspection or vessel observation register have been completed.
- Confirm there is access to all manholes and manhole lids, vents or other access points needed for initial and or top-up.
- If the initial and / or top up is via the vents; check at least two vent screens (mesh/grills) at each end of the hold have been removed and at the correct holds.
- Check all holds that are to be fumigated contain logs and there is no mixed cargo:
    - Ensure the other cargo will not be affected by the gas.
    - Seek a waiver from the cargo owner if necessary. Do not fumigate until you are in receipt of this as phosphine may damage other cargo.
- If using 1 forward or the void spaces/2nd bulkhead, check the inner manhole doors (into the holds) are opened. If not it will need opening prior to the fumigation by a team in SCBA.
- Where required have the Customer Services Team amend the dosage sheet to show what the top-up and fumigation access points are at each location if changed to address safety concerns or to enable effective fumigation. Dositubes are to be placed in the manholes, vents or other access points used for top-up. Provide the ITT with the finalised version of the dosage sheet.
- Escalate any issues that can't be resolved to the Customer Services Team.

- If the CO2 room has a Smoke Detection Unit, ensure it is switched off. This is to remain switched off for the entire the voyage. (There is no oxygen in the holds once the logs have been loaded).

7.2.2 Sealing

- Ensure all natural and mechanical ventilation that lead into the holds are closed and gas tight. Have repairs made where necessary by the ships crew.

- Seal the scuppers Fwd and Aft of each hold with tape, if required.

- Seal any fans with shrink wrap, plastic wrapping, glue or tape, if required

7.2.3 Management of 1 Forward

- 1 fwd is only to be fumigated at initial if it can be safely accessed from inside the rail.
- If 1 fwd can be safely accessed at initial but is in an enclosed space, room or can't be safely accessed inside the rail by the ITT when in transit, then it's to be fumigated at initial only, with no blankets, top-up or dositubes placed at that location.
- If using 1 forward, check the inner manhole doors (into the holds) are opened. If not, it will need opening prior to the fumigation by a team in SCBA.
- Advise the ITT that 1 forward is not being utilised and that top-up is to be applied via the 1 aft manhole, vents or other access points as applicable.
- If unsafe to access:
  - Ensure 1 fwd has been checked and made gas tight prior to the fumigation using a log bridge or ladder if there isn't another means of reaching the area inside the rail.
  - The fumigation team are not to hand over the vessel until the above has been completed.

  - As a guide, the number of flasks applied to a single manhole shouldn't exceed 25 in total, for both initial and top-up.
  - Apply the 1 forward dosage to 1 aft.
  - If this creates a large volume of pellets at the1 aft manhole and clumping is likely:
    - Split the pellet dosage between the 1 aft manhole and vents or other safe and suitable fumigation access points.
    - Have the chief officer or ship's master remove the screens / grates from the vents prior to initial fumigation.
    - Ensure the customer service team have updated the dosage sheet to reflect this for initial and top-up as required, have it amended where not.
  - Seal the vents up post application (as per the manholes).

7.2.4 Alternative Options When the Manholes Cannot Be Used

- Where manholes are in a room or enclosed space the fumigation must be set up so the ITT does not enter this space at any time, as gas levels are likely to be concentrated in this space and oxygen levels may be low.
- Also if a manhole has doglegs that are too long to bypass by using pipes or is enclosed by a solid bulkhead that doesn't allow gas to move freely into the holds:
  - The product will then will have to be applied via other hold openings.
  - This may include natural vents, hatch vents, cement access ports and may even require the dismantling and removal of mechanical venting machinery to provide good access to the holds below.
  - Where vents need to be used, have the chief officer or ship's master remove the screens / grates from the vents prior to initial fumigation.
- If using void spaces/2nd bulkhead, check the inner manhole doors (into the holds) are opened. If not, it will need opening prior to the fumigation by a team in SCBA.
- If using the cement access ports, there must be two cement access ports available per hold; port forward and starboard aft.
- Wherever possible, ensure the fumigant can be applied fore and aft in the holds to create an even spread of fumigant using more than one opening or access point.
- All fumigant access points must be safe for the ITT to access and use, plus be capable of being made gas-tight once closed.

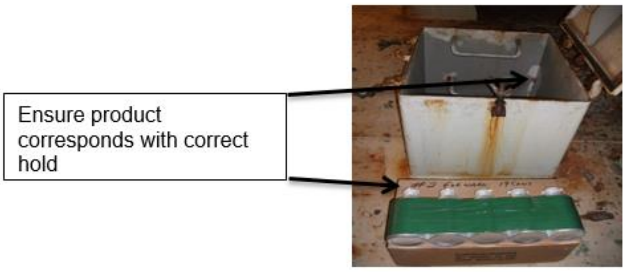
7.3 Loading the product onto the vessel

- Load the prepared product and equipment onto the man cage for the relevant crane housing and confirm it corresponds with the dosage sheet eg number 1 crane housing = 1 aft, 2 fwd initial and top up.
- Ensure the product is secured and will not fall out of the man cage.
- The forklift operator will drive to the relevant crane housing.
- Before being lifted up, ensure the workers who have entered the man cage are in the safe area behind the closed gate.
- The forklift operator must remain seated on the forklift during the entire operation.
- The forklift operator must ensure that there are no passengers on the man cage when travelling up and down the berth. They are to only be lifted up and down to and from the vessel.

- Be aware of slips and trips when moving around the vessel.
- Watch over head for any operations and or movements.
- If lashing, crane or other vessel operations start during your preparation or during application, all Genera workers are to stop work and move to a safe location until the activities have stopped (follow Section 7.2)

- Place the top up application and hessian sacks inside stores or crane housing.
- Ensure the top up product is secured and stored off the floor.

- Place the initial product at the relevant manhole ready for application.
- Ensure the manhole number and the product correspond.
- If the hold number is not present, look into the hold and see what way the logs are running, forward or aft.



8. Application

Always check for phosphine presence with your monitor and wear your mask and A2B2 P3 filter if levels are detected at or above 0.3ppm. Turn the monitor off if levels approach 10ppm to prevent saturation but keep your mask and filter on until you have moved to a location and checked and established with your monitor that phosphine levels are back below 0.3ppm.

Double check and ensure potential leak sources have been secured and natural and mechanical vents are closed and gas tight. If repairs are necessary, organise this with the crew and confirm it has been completed and now gas tight.

8.1 Preparation

- Clearly identify the man hole by observing the manhole ID number on the lid or the side of the manhole.
- Complete a visual inspection e.g. can you see logs inside the hold.
- Complete a smell test e.g. can you smell logs inside the hold.
- If no. Check with the crew members which holds the logs have been loaded into.
- If yes, open the manhole lids and secure it with the locking pin.
- Use a torch if required.

8.2 Dositubes

- Prior to the initial application, securely fix two dositubes inside each fumigation access point and or manhole as per the MPI work instruction 4A.
- If using the cement access ports, remove the bolts and lid, apply the dositubes, then replace the lid and fasten the bolts.
- There must be two cement access ports available per hold; port forward and starboard aft.
- Ensure the ITT is aware of where they have been placed so he is able to complete his checks.

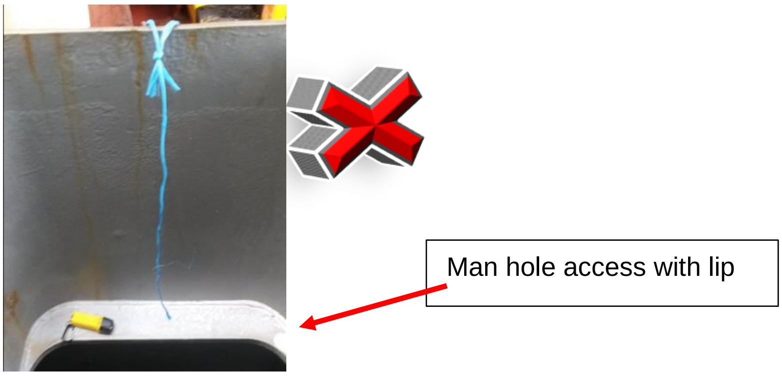
8.3 Application with Blankets

- Most blankets are supplied with six blankets in a drum and generally one drum is for each manhole.
- A mask and filter must be worn at all times when the fumigant packaging is open or being opened, during application plus after hatches and vents are closed and at any other time if the phosphine monitor returns readings of 0.3ppm or higher.

- Use SCBA gear if you are required to enter the hold. Only workers with current SCBA and confined space entry training and certification are permitted to do this, there must be another staff member in SCBA also trained to support the person entering the hold.
- Do not apply blankets to manhole 5 AFT, unless otherwise directed on the dosage sheet.
- Tie a knot in the string so it will loop over the wingnut hinge.
- Tie the blankets in half and "horseshoe" them where required if this helps maintain separation between the blankets.

- Remove the lid from the drum.
- Remove the foil bag from the drum and cut the bag open with a knife.
- Immediately remove the blanket from the foil bag and place on the deck.
- Keep the blanket away from your face.
- If there is smouldering or a fire, roll the blanket out immediately on the deck.

- With the string tie a double knot around the blanket at least 30cm from the end of the blanket.
- Do not tie the string through the eyelet.
- To avoid cutting of the string while in transit, do not tie the string on the side of the man hole access where there is a lip.



- Ensure all blankets are fully unrolled before hanging.
- Place the blankets down the manhole between the grating.
- If the grating is in mesh form, hang the blankets above the grate.
- Attach the string to the secured devices on the manhole.
- Attach the string to the ladder if the manhole has a wheel type securing device.
- DO NOT attach the strings to the manhole lids.


- Tie and hang all blanket's required for this manhole as per the above procedures.


- Place the empty foil bags back into an empty drum with out the lid on, ready for removal from the vessel.
- Proceed to the next manhole and repeat the above procedures.
- If there are no pellets to be applied:
  - Close the manhole lid and ensure the blankets or dositubes do not detach.
  - Tighten each nut of the manhole cover, vent or hatch evenly, avoiding tightening one side too tight at first.

8.4 Application with Pellets

- Put on your full-face mask with a new filter.
- Use SCBA gear if you are required to enter the hold. Only workers with current SCBA and confined space entry training and certification are permitted to do this, there must be another staff member in SCBA also trained to support the person entering the hold.
- Remove the flask from the box.
- Open the flasks with a spanner or flask opener.
- Keep the flask away from your face as flasks can be under pressure and can release gas when opened.
- Sprinkle or pour the pellets into the manhole.
- Distribute the pellets in the man hole area as best as you can.
- Apply all flasks required for this manhole as per the above

procedures.

- Use a PVC pipe or water tubing if the holds have dog legs and ensure the pellets bypass the dog leg.


- Place the empty flasks back into the box without the lids on, ready for removal from the vessel.
- Proceed to the next manhole and repeat the above procedures.

8.5 Securing the Manhole lid

- Remove the safety device and close the manhole lid using both hands.

- Ensure the blankets or dositubes have not detached from the lid.
- Secure the manhole lid with the wing nuts:
  - Do not overtighten.
  - Work around the lid.
  - Keep tightening the nuts until they are all tight.
- Secure a warning sign to the top of the manhole lid, use spray glue if required.
- Write the start time, start date and the total exposure period of 264 hours on the sign.

9. Departure from the Vessel

- Place any rubbish into the drums or boxes and remove from the vessel.
- Ensure all rubbish is removed.
- Ensure all top up product has been checked and secured in the correct location.
- Ensure there are sufficient hessian sacks stored on the vessel.
- Ensure the ITT has signed all relevant paperwork.
- Complete and sign the IT4 and IT5 and handover copies to the captain.
- Update the captain or chief officer that the initial application has been completed.
- Brief the ITT and ensure they understand the top up procedure, where the fumigation access points are for the top-up (manholes, vents, cements ports etc) .
- Check this is reflected on the dosage sheet, have the Customer Services Team update it where required.

- Ensure the ITT has all their safety equipment for their voyage:
  - Two calibrated phosphine monitors.
  - Sufficient PPE and filters
  - Three spare dositubes and magnetic clamps
  - Spikes for walking on logs
- Port of Napier Only – ensure all procedures have been completed by the technician in charge and ITT for the IT20 Pilot Checklist.
- Complete and return all paperwork to HO – Customer Service Team.
- On return to your office/portacom, ensure the empty flasks and lids are triple rinsed, punctured and disposed in a approved landfill/recycling.

10. Document Review History

Date	**Document Name and Version**	**Reviewer**
June 2016	SOP 10.4 Phosphine Application to Vessel Holds V6.0	Mike Goss
March 2017	SOP 10.4 Phosphine Application to Vessel Holds V7.0	Michelle Pomare
June 2017	SOP 10.4 Phosphine Application to Vessel Holds V8.0	Michelle Pomare /Gavin Smales
November 2017	SOP 10.4 Phosphine Application to Vessel Holds V9.0	Gavin – Operations / Michelle - Admin
January 2018	SOP 10.4 Phosphine Application to Vessel Holds V9.1	Michelle - Admin
December 2018	SOP 10.4 Phosphine Application to Vessel Holds V10.0	Robert Maassen
January 2020	SOP 10.4 Phosphine Application to Vessel Holds V10.1	David Baker / Operations Managers / Michelle - Admin

SAFE OPERATING PROCEDURES

SOP13.1 Phosphine Residue Removal & Vessel Gas Free V3.1

Responsibility:	Line Managers are responsible for ensuring workers have access to this document, receive instruction, training and supervision from a competent person, who signs off the trainee when they have demonstrated competence with this procedure. All workers on site have a responsibility to ensure this procedure is followed. All workers have a responsibility to report new hazards or unsafe conditions that are identified. The Compliance & Safety Team manage and maintain the Safe Operating Procedures with input from workers, Health & Safety Reps and Line Managers.
Review details:	Annually before September 2020 or as required following changes

All operations must be carried out in conjunction with;

- *The Control and Safe Use of Fumigants. Pest Management Association of New Zealand Code of Practice.*
- *Any operating rules issued by the PCBU who manages or controls the site you are operating at.*
- *Genera Hazard/Risk Register – H32 V23*
- *Daily tool box meeting.*
- *Genera's MPI approved phytosanitary procedures.*
- *Aluminium Phosphide Safety Data Sheet*
- *Workplace Exposure Standards*
- *International Maritime Dangerous Goods Code Safe Use of Respirators Policy*
- *PFD Water Hazard Policy (Personal Flotation Device)*

Personal Protection Equipment (PPE) required;

- *Hard Hat*
- *Steel toe footwear*
- *Hi visibility clothing*
- *Gloves*
- *SCBA*
- *Full face mask*
- *New Phosphine filter to be used, A1B1E1 filter, with three colour rings – brown, grey and white*
- *Two Calibrated Phosphine Monitors*
- *Personal Flotation Device (if within 1m of an unguarded waters edge)*

Vehicles requirements;

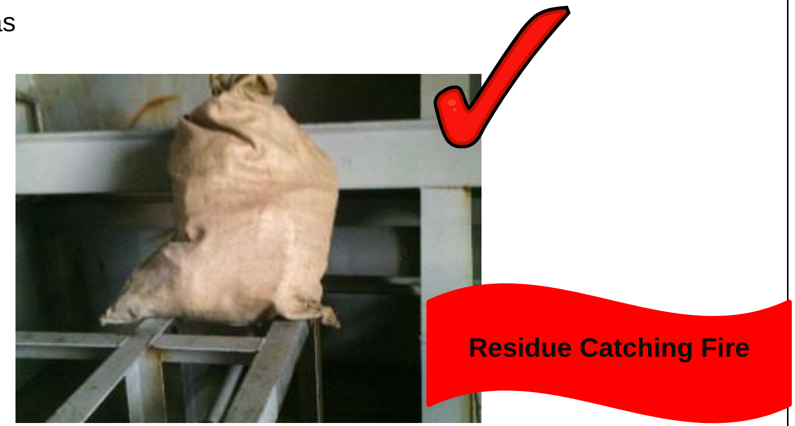
- *Headlights on*
- *Flashing Beacon on*
- Raised Vehicle Flags, if applicable
- Do NOT have vehicle hazard lights on.

1.0 Purpose

To safely remove and quench Phosphine residue, check vessel holds and issue Gas Free certificate.

2.0 Assessment

- Confirm vessel name and berth location
- Notify ships agent and stevedores of your intention to collect residue and issue the Gas Free certificate
- Check the vessel has completed ventilation before berthing and the required fumigation period has been completed
- Check what fumigant was used for the in hold cargo – Phosphine pellets and or blankets
- Check which holds were fumigated
- Advise vessel of your intention to collect the residue and issue Gas Free certificate
- Have a available a gas free certificate and or a residue removal form.
- Ensure no crew or contractors are on deck before issuing the gas free certificate.
- Check residue will be collected and placed in a well ventilated dry area on the vessel eg in the store rooms on deck. Residue includes blankets in a hessian sack and empty flasks in a box.
- Blankets are NOT to be placed in a sealed drum or bag, always store in breathable sack eg hessian sack, 4 blankets per sack, fill only half of the sack
- Blankets are NOT to be placed in a confined or wet area
- Ensure signs are used for storage areas



3.0 Preparation

- Update ships agent and stevedores the date and time you will board the vessel and have work completed

Prior to boarding the vessel:

- Ensure appropriate PPE gear is worn – full face mask, new filter, gloves, overalls and steel toe footwear
- Introduce yourself to the officer at the gangway and advise you are to collect the residue and issue Gas Free certificate
- Ensure the Captain or Chief Officer is aware you are on board and your purpose
- Reconfirm with the Captain or CO that ventilation has been completed prior to berthing.
- Proceed to check gas levels of each hold by using a monitor

Retrieving Blankets that have fallen into the vessel holds:

- Use a hook either on a string or a long pole, to retrieve the blanket without entering the hold.
- If the above is not successful, ensure the holds are gas free and instruct the crane operator to retrieve the blanket by using the crane scoop.
- The blanket is to then be removed from the bucket by a Genera trained technician or contractor.

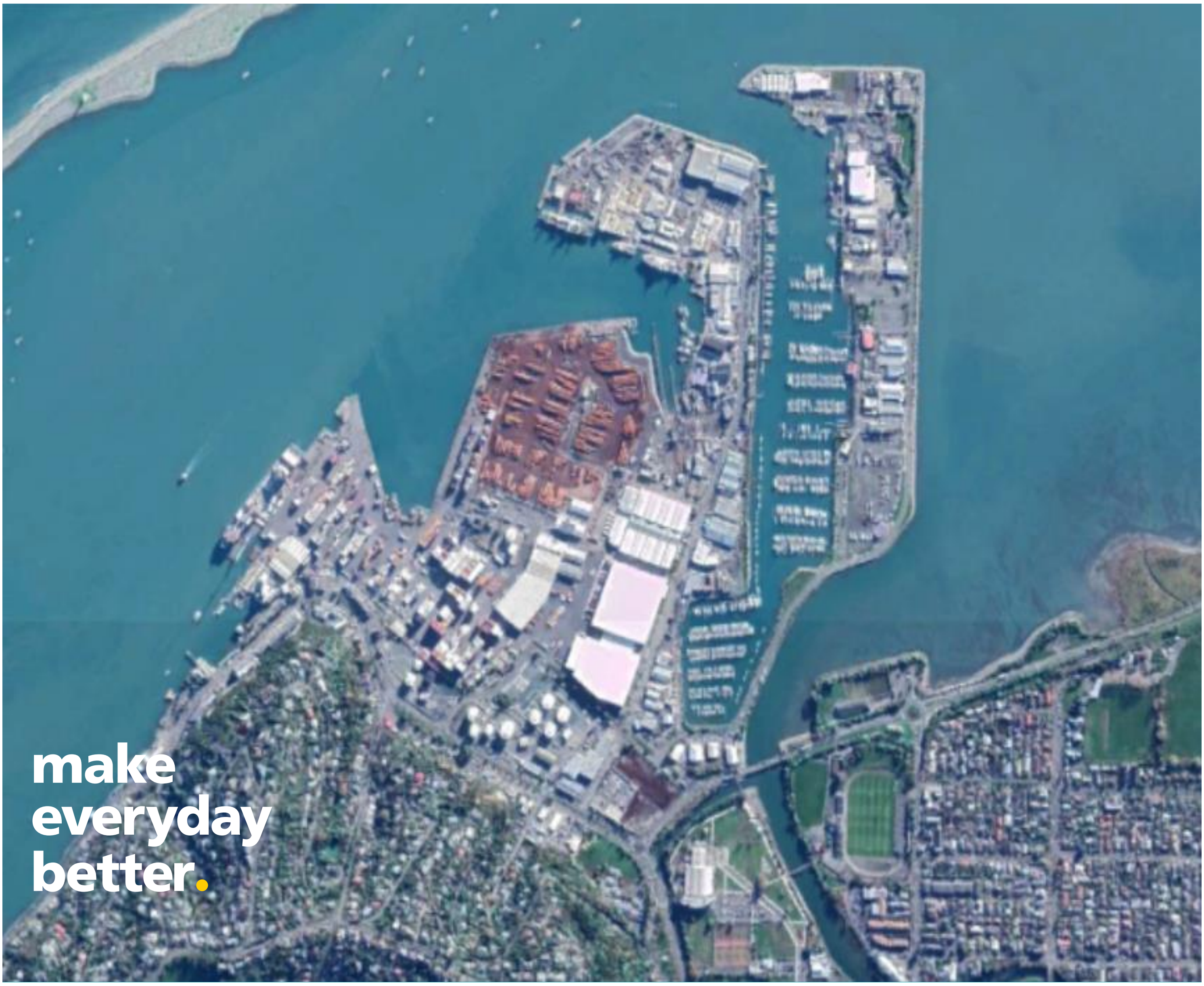
4.0	Process
	• Check all residue has been collected from all holds and store rooms on deck and all crane housing rooms. • Issue the Gas Free Certificate and or the residue removal form to the Captain, copy both forms for the Genera Customer Service Team. • Update the Captain or Chief Officer, ships agent and stevedores that the residue has been collected and the vessel is Gas Free **Transporting Active Residue** • To be transported on an open load/deck of a ute or truck • NEVER transport inside a cab or inside a storage/load area of a closed van • Dispose of residue and empty flasks and boxes in the appropriate manner. • Do NOT pour any residue water into storm water drains **Deactivation Process** • The Genera technician in charge is to supervise the below process: • Ensure you have adequate number of drums (55 gallon drums) with water upto 5cm from the top of the drum • Ensure you have adequate number of steel chains • Additional water is to be available from a hose or container, if a hose is not available the container is to be 50% volume of the drums used • Ensure an adequate amount of liquid soap is added to the water. • Regularly check gas levels in the air space to ensure the risk area is not exceeding WES of 0.3ppm • Stand up wind from the drum • Remember phosphine gas is flammable in air • Immerse residue into the drum and hold in position with steel chains • Ensure all residue is contained in the drum and kept below the water level • The residue is deactivated when no gas bubbles are rising in the water eg no gas is released from the residue **After Quenching Residue** • Remove blankets from the drums and leave to drain • Take care with handling light loose powder by wearing the correct filter with your full face mask • Powder residue and blankets are to be placed in hessian sacks, Blankets are NOT to be placed in a sealed drum or bag, always store in breathable sack eg hessian sack • Ensure quenching areas are left clean and tidy
5.0	**After Collection**
	• Notify Genera Customer Service Team the work has been completed and forward a copies of the gas free certificate and or residue removal form. • Ensure all residue has suitably disposed of.
6.0	**Completed**

Port Nelson - Discharges to Air from Fumigation Activities Technical Assessment

Prepared for Genera Limited

Prepared by Beca Limited

23 January 2020



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Revision History

Revision Nº	Prepared By	Description	Date
1	**Suzanne Cawood / Mathew Noonan**	1st Draft	23 January 2020
2.			

Document Acceptance

Action	Name	Signed	Date
Prepared by	**Suzanne Cawood / Mathew Noonan**		
Reviewed by	**Prue Harwood**		
Approved by			
on behalf of	Beca Limited		

1 Introduction

1.1 Background

Genera Biosecurity Limited (**Genera**) currently provides fumigation treatment services at Port Nelson (the '**Port**'), Nelson City for bio-security purposes. All fumigation activities occur in a secured area within the Port.

Goods that require fumigation are treated with the fumigant methyl-bromide (MB). Re-capture technology is used at the Port to minimise the discharge to air of MB after all fumigations. However, small amounts of the fumigant are still emitted to the atmosphere.

Genera currently holds a resource consent (Resource Consent Number RM085422) from Nelson City Council (**NCC**) which authorises the discharge to air of MB from the fumigation activities. The resource consent is due to expire on 1 September 2020. A copy of the current consent is provided in Appendix A of this report.

Genera wish to continue their existing fumigation operations at the Port and are applying to NCC for a new resource consent. Under Rule AQr.41.2 of the operative Nelson Air Quality Plan (**NAQP**)[1] discharges to air from a fumigation activity is a Controlled Activity provided it complies with the rule's standards and meets the matters of control. Rule AQr.41.2 is reproduced in Appendix D.

Genera has commissioned Beca Limited (Beca), to provide a technical assessment of the discharges to air from the proposed fumigation operations at the port. The assessment will be used to support Genera's application to NCC.

1.2 Scope of the report

This report is intended to accompany an application for a resource consent for air discharges from the fumigation shed at the Port. Potential effects of the discharges to air have been assessed using dispersion modelling methods. Downwind MB concentrations have been predicted using the CALPUFF dispersion model. Predicted downwind concentrations have been compared against the relevant air quality guidelines and standards.

This report describes the activity and the environmental effects of the discharges and includes:

- A description of the fumigation process and the discharges to air from the operation;
- An assessment of the receiving environment in terms of sensitivity of the receiving environment to adverse air quality effects, meteorological influences and background pollutant levels
- Relevant air quality guidelines and standards
- An assessment of the effect of the discharges to air on the receiving environment; and
- A summary of conclusions and findings of the investigation.

[1] Nelson City Council, 2008. *Nelson Air Quality Plan*. Operative 3 November 2008.

1.3 Reference Documents

This document has been prepared in accordance with the guidance provided by the Ministry for the Environment *Good Practice Guide for Atmospheric Dispersion Modelling* (2004) (GPG Dispersion Modelling)[2]

1.4 Other Relevant Resource Consents

The discharge of MB to air from the passive degassing (or desorption) of MB from fumigated products was approved as a Restricted Discretionary activity on 15 November 2010 (RM105300). This consent also expires on 1 September 2020. A separate application will be made to renew this consent.

1.5 Limitations

This report has been prepared by Beca for Genera. Beca has relied upon the information provided by Genera in completing this document. Unless otherwise stated, Beca has not sought to independently verify the information provided. This document is, therefore, based upon the accuracy and completeness of the information provided and Beca cannot be held responsible for any misrepresentations, incompleteness, or inaccuracies provided within that information. Should any new or additional information become available, this report will need to be reviewed accordingly.

[2] Ministry for the Environment, 2004, *Good Practice Guide for Atmospheric Dispersion Modelling*, ISBN:0-478-18941-9

2 Description of the Proposal and Discharges to Air

2.1 Overview of the Process

A range of commodities which are exported from the Port are required to undergo pre-shipment fumigation for quarantine purposes. Similarly, the Ministry for Primary Industries (MPI) requires some imported goods (or their associated dunnage) to also undergo fumigation for bio-security reasons.

All fumigations utilising MB which occur at the Port are undertaken by Genera. All the fumigations occur within a secure area of the port. MB is a colourless, and odourless gas and is widely used as a fungicide, herbicide and insecticide.

Goods are fumigated with MB in either shipping containers or under a gas-proof tarpaulin within a dedicated fumigation shed. Genera estimates that during a typical year more than 92 % of the total MB used at the port is used for shipping container fumigations, and less than 8 % for shed based fumigations. Most fumigation at the port are undertaken for pre-shipment quarantine purposes.

All shipping container fumigations occur outside on a concreted area. Genera estimates that on average approximately 6 - 12 containers may be fumigated per shipment.

Genera estimates that the fumigation shed is used approximately 24 times per year, although this may vary. Currently only imported goods are fumigated in the shed.

During a fumigation, a specified dosage of MB is injected into a shipping container or under a gas-proof tarpaulin. The MB dosage rate used in the fumigation can vary between 24 g/m^3 and 120 g/m^3 depending on quarantine requirements[3]. Therefore, depending on the dosage rate the quantity of MB injected into a standard '40 ft high cube' shipping container (with an internal volume of 76.4 m^3) could vary between 1.83 kg to 9.17 kg, and between 0.80 kg to 3.98 kg for a standard '20 ft' shipping container (with an internal volume of 33.2 m^3).

However, MB dosage rates at the port are typically between 24 g/m^3 and 72 g/m^3.[4] The weighted average MB dosage rate in 2018 and 2019 was 58 g/m^3 (average weighted with respect to the volume of material fumigated). The maximum MB dosage rate used at the port of 120 g/m^3 is rarely used and only one shipping container was fumigated at 120 g/m^3 between 2018 and 2019[5].

Goods are treated with MB for a specified time period. Treatment times depend on quarantine requirements and may last up to 24 hours. During this time some of the injected MB is absorbed by the fumigated goods and dunnage. This process is called 'sorption'. The amount of sorption which occurs depends on the porosity of the material. Higher sorption rates are generally observed for timber products compared to other products (e.g. machinery, vehicles, building materials, and primary produce).

After the treatment period, the fumigated shipping containers and goods under tarpaulins are mechanically ventilated. The ventilation air passes through a MB recapture unit before being discharged to the atmosphere through a short vent. The top of the discharge vent is approximately 2.0 - 2.5 m above ground level and angled in a roughly horizontal direction.

[3] MB dosage rates are specified to be either 24, 48, 64, 72, 80, 96 or 120 g/m^3.

[4] 77.5% of the fumigation undertaken in 2018 and 2019 used a dosage rate of 24 g/m^3 to 72 g/m^3.

[5] The peak 120 g/m^3 dosage rate is a pre-shipment quarantine requirement for timber exported to China for temperatures between 5 - 15°C.

The goods treated in the fumigated shed are ventilated to an external MB recapture unit.

Genera uses an activated carbon (AC) recapture system at the port. The ventilation air from the treated shipping containers and tarpaulins is vented through an AC bed which absorbs the MB. As a consequence only very small quantities of the fumigant are discharged to air. The MB recapture unit is shown in Figure 2-1.

The AC is replaced when the bed's absorption capacity is reached. Genera monitors the concentration of MB which is discharged from the recapture unit vent. When the MB discharge concentration approaches 5 ppm the ventilation procedure is halted and the AC bed is replaced before any further ventilation continues. The used activated carbon is then transported off-site for disposal.[6]

The same recapture system is used for both the shed and the shipping container fumigations. All treated goods at the Port are ventilated through the recapture system.

Figure 2-1. Genera's Port Nelson methyl bromide recapture system in operation

[6] Genera Lt, 2019. *Safe Operating Procedures. SOP 2.2 Fumigation of Containers with Methyl Bromide – Version 9.1*

The recapture continues until the measured concentration of MB in the airspace of the shipping container or the tarpaulin is below the New Zealand occupational workplace place exposure standard (WES)[7] of 5 ppm (or 19 mg/m^3)[8]. MB concentrations are measured every 10 minutes.

Recapture periods commonly vary between approximately 2 to 12 hours depending on the goods being fumigated. Generally timber products are ventilated for 12 or more hours. A maximum of three shipping containers are ventilated at any time at the port.

After recapture, the doors of the shipping containers are opened for a short period of time so the fumigation equipment inside the containers can be removed. The containers are then resealed, and a desorption sticker is placed on the container doors to indicate it has been fumigated and ventilated. The container remains sealed while it is in the Port awaiting shipment. A container would commonly remain at the Port for 1 to 7 days before being shipped.

Similarly, for goods treated in the fumigation shed, the covering tarpaulin is removed after the ventilation, and a desorption sticker is placed on the door of the shed to indicate the items inside have been fumigated and the MB recaptured. Genera estimates that most of the treated goods in the shed are stored for no more than 1 -2 days.

2.2 Annual Methyl-Bromide Usage Rates

The annual amount of MB used at the port varies depending on the demand. The average annual usage of MB at the port between 2018 and 2019 was approximately 1.2 t/year. However annual usage rates vary from year-to-year.

The existing resource consent allows for up to 4.3 t/year of MB to be used in fumigations carried out under gas-proof sheets. No limitation is placed on the amount of MB which is used to fumigate shipping containers.

Genera is seeking to maintain a MB usage limit of 4.3 t/year which would cover all fumigation activities at the port (i.e., shipping container and shed fumigations).

2.3 Emission to Air

Most of the MB used at the port is recaptured during ventilation and therefore is not discharged to the atmosphere. Therefore, only relatively small quantities of MB are emitted to the air from the port fumigation activities. The potential emission source of MB includes the following;

- The discharge of any residual MB which remains in the ventilation air after passing through MB recapture system;
- The residual MB which is discharged after ventilation when the doors of the shipping containers are opened, and when the tarpaulins are removed from the treated products in the fumigation shed; and
- The desorption of MB from treated goods stored in the fumigation shed once the tarpaulins are removed after ventilation.

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[7] Worksafe, 2019. *Workplace exposure standards and biological exposure indices*. 11th Edition. November 2019

[8] The WES is expressed as am 8-hour time weighted average (TWA) concentration.

2.3.1 Emission During Ventilation Operations

AC emission control systems are widely used in industrial and commercial applications to minimise the discharge of air containments due to the effectiveness of AC to remove air containments from discharged air flows. AC systems can be expected to have high scrubbing efficiencies (i.e., the percentage of MB that is absorbed by the AC bed), provided the system is appropriately sized and maintained. MB scrubbing efficiencies of greater than 99% and 99.9% have been reported by different agencies for AC based recapture system[9][10].

Beca understands that the scrubbing of the recapture system used at the Port has not been directly measured (although the system's recapture rates have been assessed), however, similar scrubbing efficiencies can be expected for the recapture system used at the Port.

The quantity of MB which is annually discharged during ventilation has been estimated by multiplying the annual MB usage rate at the port by the proportion of MB which is not absorbed by the AC recapture (i.e., 100% - scrubbing efficiency %). For this assessment a conservative scrubbing efficiency of 99 % has been assumed for the AC system.

This approach is expected to overestimate emission rates as it does not account for the proportion of MB which has not desorbed during ventilation, or which remains in the airspace of the treated shipping containers and tarpaulins after ventilation.

Genera has proposed a maximum MB usage limit of 4.3 t/year for fumigation operations at the port. Using the above methodology, the annual emission rate of MB from ventilation can be estimated to be 43 kg/year (i.e. 1% x 4,300 kg/yr). Similarly, the annual MB emission rates for more typical annual MB usage rates of 1.2 t/year can be estimated to be 12 kg/year.

The estimated annual emission rate estimated indicates that only comparatively small quantities of MB is emitted to the atmosphere during ventilation operations at the port.

Short term MB emission rates at the port will vary with regards to the number of ventilations which occur at any time and the MB dosage rates. At most, three ventilations can occur at the same time (i.e. three shipping containers).

MB discharge rates from each recapture unit can be estimated by multiplying the MB discharge concentration by the recapture's unit ventilation rate.

The recapture unit's ventilation fan has a maximum air flow rate of 1,000 m^3/hr. Therefore, if the MB concentration discharged from the air vent is assumed to be 5 ppm (19 mg/m^3) (the AC bed replacement threshold) the maximum MB discharged from each unit is calculated to be 0.019 kg/hr (or 0.0053 g/s). The total MB discharged from three ventilations occurring simultaneously at any time can therefore be estimated to be 0.057 kg/hr (or 0.0158 g/s).

The predicted emission rate from the recapture unit when ventilating goods in the fumigation shed are less than the discharge rate of 2.2 g/s specified under controlled activity Rule AQr.41.2 condition v)a. Similarly, the predicted maximum emission rate, when all three recapture units are in operation, is less than the

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[9] MBTOC. 2014. 2014 assessment report of the Methyl Bromide Technical Options Committee. Montreal Protocol on Substances that Deplete the Ozone Layer, United Nations Environment Programme, Ozone Secretariat, Nairobi, Kenya. 277 pp.

[10] USEPA, 2015. Methyl Bromide Field Operation Guidance (MB FOG) Report (April 13, 2015).

maximum of emission rate limit of 2.2 g/s specified under controlled activity Rule AQr.41.2 condition vi). The results indicate discharges from the shed would be expected to comply with conditions v)a and vi).

Overall the results indicate that the maximum discharge rate of MB during ventilation is low and emissions are unlikely to have a significant effect on ambient air concentrations outside the port boundary.

2.3.2 Fugitive Emissions at the End of the Ventilation Period

Small amounts of MB will also be emitted after the ventilation period when the doors of the shipping containers are opened and when the tarpaulins used in the fumigation shed are removed.

Genera's operational procedures require that mechanical ventilation continues until the measured concentration of MB in the airspace of the fumigated volume is below 5 ppm (19 mg/m^3). Therefore, if the MB concentration in the airspace of a standard '40 ft high cube' shipping container is assumed to be 5 ppm at the end of ventilation, the total amount of MB which could potentially be released to the atmosphere when the container doors are opened is estimated to be 0.00145 kg (i.e., 0.000019 kg/m3 x 76.4 m^3)

A maximum of two '40 ft high cube' shipping containers can be fumigated at any time in the fumigation shed. Therefore, the maximum fugitive emission of MB from these containers after ventilation when the tarpaulin is removed can be estimated to be 0.0029 kg (i.e. 2 x 0.00145 kg).

Based on the average volume of goods fumigated between 2018 and 2019 (i.e. 20,234 m^3) the typical annual emission rate of 0.38 kg/year can be estimated (i.e. 0.000019 kg/m3 x 20,234 m^3).

If MB usage at the port were to increase to the proposed consent limit of 4.3 t/year the annual MB emission rates can be pro-rated from those predicted for 2018 and 2019 to be 1.41 kg/year.

The results indicate that the quantity of MB emitted during these operations is negligible. Any discharge would not be expected to have any substantial impact on air quality levels outside of the Port Security Area.

2.3.3 Desorption Emissions During Storage

During the treatment period a proportion of the MB dosage is absorbed by the treated commodities and dunnage. The absorbed MB is mostly desorbed during the recapture/ventilation period and is therefore ventilated through the recapture unit. However, a proportion of the absorbed MB can remain after recapture and slowly desorb during storage.

After ventilation operations, the shipping containers are only opened for a short period to allow for the monitoring equipment inside the container to be removed before the containers are again resealed. The shipping containers are tested for their air tightness prior to fumigation occurring. Therefore, once resealed any MB which desorbs is expected to be contained within the shipping containers and therefore would not be discharged to the atmosphere.

In contrast, goods which have been treated in the fumigation shed may remain uncovered for 1 to 2 days after ventilation before they are transported off site. During this period any residual MB which remains in the treated goods can desorb and discharge into the fumigation shed's airspace and over time into the atmosphere.

The proportion of MB which is absorbed during treatment and which subsequently desorbs would vary significantly depending on the porosity of the treated material. Very low MB sorption rates are recorded for metal items, machinery, vehicles and most building materials (typically <2%[11]). Therefore, any absorbed MB is expected to desorb during the ventilation period.

However, substantially higher sorption rates are reported for treated wood products. Hall et al[12] reports up to 51% – 61% of the initial MB dosage which is applied to *Pinus radiata* logs may be absorbed during the treatment period. The absorbed MB during the trial was observed to gradually desorb at the end of the treatment period, with the desorption rates decreasing over time.

Therefore, MB desorption emissions at the port are expected to be greatest when wood products are fumigated in the shed. The emission rates will increase in proportion to the MB dosage (i.e. the volume of goods fumigated x the dosage rate).

Maximum MB dosage would be expected to occur if two '40 ft high cube' shipping containers of wood products (with a combined volume of 152.8 m^3) were to be fumigated at the MPI maximum prescribed dosage rate of 80 g/m^3[13]. For this scenario the total MB dosage would be 12.2 kg.

The MB desorption rates from the wood products have been estimated using the formula derived by Hall et al based on the observed desorption of MB from *Pinus radiata* logs. The formula is shown below;

$$Rate / Dose = R_o \exp(-kt^p)$$

Where:

Rate = MB desorption rate (g/h.m³)

Dose = MB treatment dosage (g/m³)

t = time since fumigation (hour)

$R_o = 0.134$

$k = 0.84$

$p = 0.48$

The estimated MB desorption rate with respect to time is shown in Figure 2-2. Wood products at the Port are typically mechanically ventilated for more than 12 hours before the MB concentrations in the shipping container and tarpaulin airspaces can be maintained below the WES of 5 ppm.

Therefore, it is assumed that the desorption rate which is predicted 12 hours after treatment has occurred is representative of the maximum desorption rate which is likely to occur in the fumigation shed when the tarpaulins are initially removed.

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[11] Corsi R L., Walker MB.,. Liljestrand H M., and. Hubbard H F., Poppendieck, DG., 2007. *Methyl Bromide as a Building Disinfectant: Interaction with Indoor Materials and Resulting Byproduct Formation*. J. Air & Waste Manage. Assoc. 57:576–585

[12] Hall M, Najar-Rodriguez A, Adlam A, Hall A and Brash D., 2016. *Sorption and desorption characteristics of methyl bromide during and after fumigation of pine (Pinus radiata D. Don) logs*. Pest Manag Sci 2017; 73: 874–879.

[13] Ministry for Primary Industries, 2019. *Treatment Requirement: Approved Biosecurity Treatments*. 22 July 2019

The maximum desorption rate from the treated the wood products after the 12 hours ventilation period is predicted to be 0.0285 g/s. At the end of the 2-day storage period, emission rates are predicted to be 0.0011 g/s.

The predicted emission rate is less than the discharge rate of 1 g/s specified for the controlled activity Rule AQr.41.2 condition v)b. The maximum predicted MB desorption rate after ventilation is predicted to be less than 2.9% of the condition's emission limit. The results indicate discharges from the shed would be expected to comply with condition v)b.

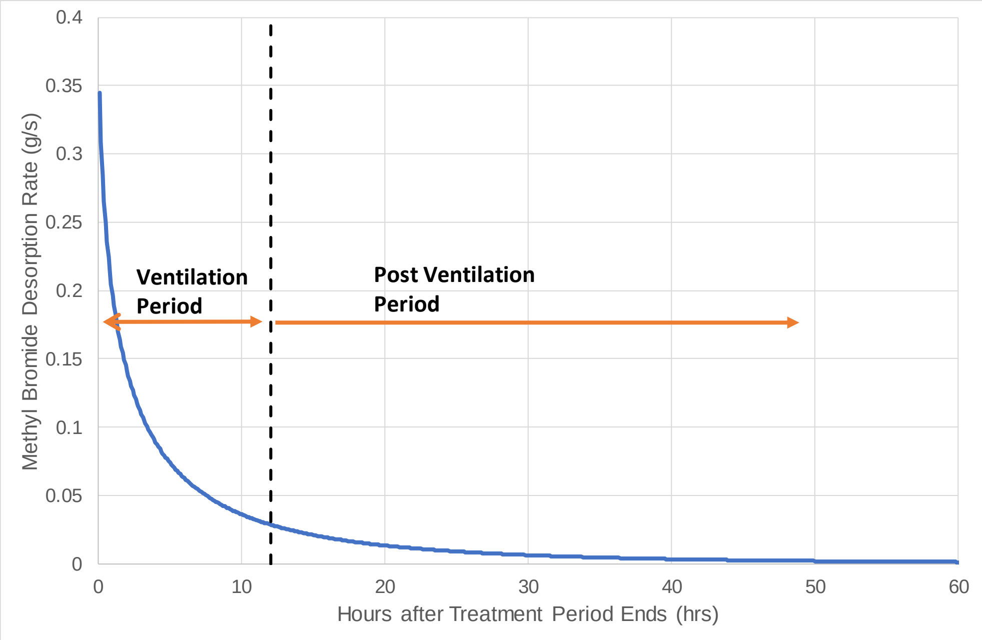


Figure 2-2. Predicted methyl bromide desorption rate (g/s) post-treatment for two '40 ft high cube' shipping container containing wood products which have been dosed at 80 g/m^3.

Desorption rates within the shed will vary significantly depending on the type of products fumigated and the dosage rates used. Estimating annual emissions from desorption processes is therefore complex given the variability of conditions between each fumigation.

In this assessment a conservative screening approach has been used to estimate annual emission rates. The screening approach has assumed the following;

- only wood products are fumigated in the shed;
- desorption rates from the goods vary over time in accordance with Hall et al's formula;
- all of the treated goods in the fumigation shed are stored for 2 days;
- all of the volume under the tarpaulins which is fumigated is occupied by wood products (i.e. there are no free spaces under the tarpaulin);

These assumptions will overestimate the amount of MB that is absorbed and subsequently desorbed during storage.

Genera estimates that 8% of total MB used at the port is used for fumigation in the shed. Therefore, based on Genera's proposed MB annual usage limit of 4.3 t/year, approximately 343 kg/year of MB could be expected to be used for fumigations in the shed.

Hall et al's formula predicts that 9.76 % of the initial MB dosage could potentially be desorbed over the 2-day storage period after an initial 12-hour ventilation period. Therefore, based on the estimated usage of MB in the fumigation shed, a total of 33.5 kg/year of MB can be estimated as being discharged during desorption.

Similarly, for a more typical annual MB usage rate of 1.2 t/year an annual desorption rate of 9.3 kg/year can be calculated for the fumigation shed.

2.4 Summary of the Emissions to Air

A summary of the estimated annual emissions of MB from the port fumigation activities is shown in Table 2-1. The table shows the maximum emissions for the proposed MB usage consent limit 4.3 t/year and for the more typical usage rate of 1.2 t/year.

Table 2-1. Summary of the estimated annual emissions of MB (kg/yr) from the fumigation operations at Port Nelson

Emission Source	Proposed maximum MB usage rate limit of 4.3 t/year	Typical annual average MB usage rate of 1.2 t/year
Discharges during mechanical ventilation (kg/yr)	43.0	12.0
Discharges at the end of the ventilation period (kg/yr)	1.4	0.38
Discharges from desorption (kg/yr)	33.5	9.3
Total Emission (kg/yr)	**77.9**	**21.68**

3 Receiving Environment

3.1 Site location

The proposed fumigation activities will occur at Port Nelson, Nelson. The proposed fumigations will occur in a secured area of the port where existing fumigation currently occurs. The location where fumigation will occur is shown in Figure 3-1.The port's 'Port Security Area' boundary is also shown in the figure as a red outline. There is no public access to this part of the port.

Fumigations will occur in either an enclosed fumigation shed or in shipping containers located on an adjacent concrete pad. The fumigation shed and treated shipping containers are located more than 140 m from the 'Port Security Area' boundary and more than 290 m from the Main Wharf, where cruise ships berth. The closest point outside the 'Port Security Area' is a carpark area.

The site is located within the 'Airshed C' which incorporates all of the port, most of Nelson's commercial and industrial areas, and the residential areas located on the eastern side of the Maitai River. The airshed has been gazetted in the National Environmental Standards for Air Quality (NESAQ).

Figure 3-1. Location of the Fumigation shed within Port Nelson (red outline), and surrounding area (imagery sourced from GoogleEarth – 2019 Maxar Technologies)

3.2 Surrounding Land Use and Sensitivity

Figure 3-2 shows the zoning of the surrounding land use under the operative NRMP. The area which immediately surrounds the port is industrial in nature and is primarily connected with port activities. This area is zoned Industrial under the Nelson Resource Management Plan (NRMP).

However, the port area also includes the Nelson Marina which provides berthing facilities for small boats. The closest berth is located approximately 550 m to the east of the fumigation activities.

Areas zoned 'Suburban Commercial' and 'Residential', under the NRMP are located to the south of the port on the southern side of State High 6. The closest residential property is located approximately 475 m to the south of the port's fumigation area. Dwellings also occupy the hills located to the south of the port.

Two recreational areas, Rutherford Park and Trafalgar Park, are more than 850 m to the south-west of the port's fumigation area. Nelson's 'Inner City Centre' is located more than 1.3 km south from the fumigation shed.

Receptors which are considered to have a high sensitivity to adverse air quality effects are the nearby residential and recreational areas. At these locations people with a high sensitivity to adverse air quality effects (including children, the elderly and infirmed) may be present and potentially exposed to emissions from the port.

However, these areas are located some distance from the fumigation activity. Air contaminants disperse and dilute with increasing downwind distance. Therefore, any MB emitted from the port is expected to be well dispersed before reaching these receptors.

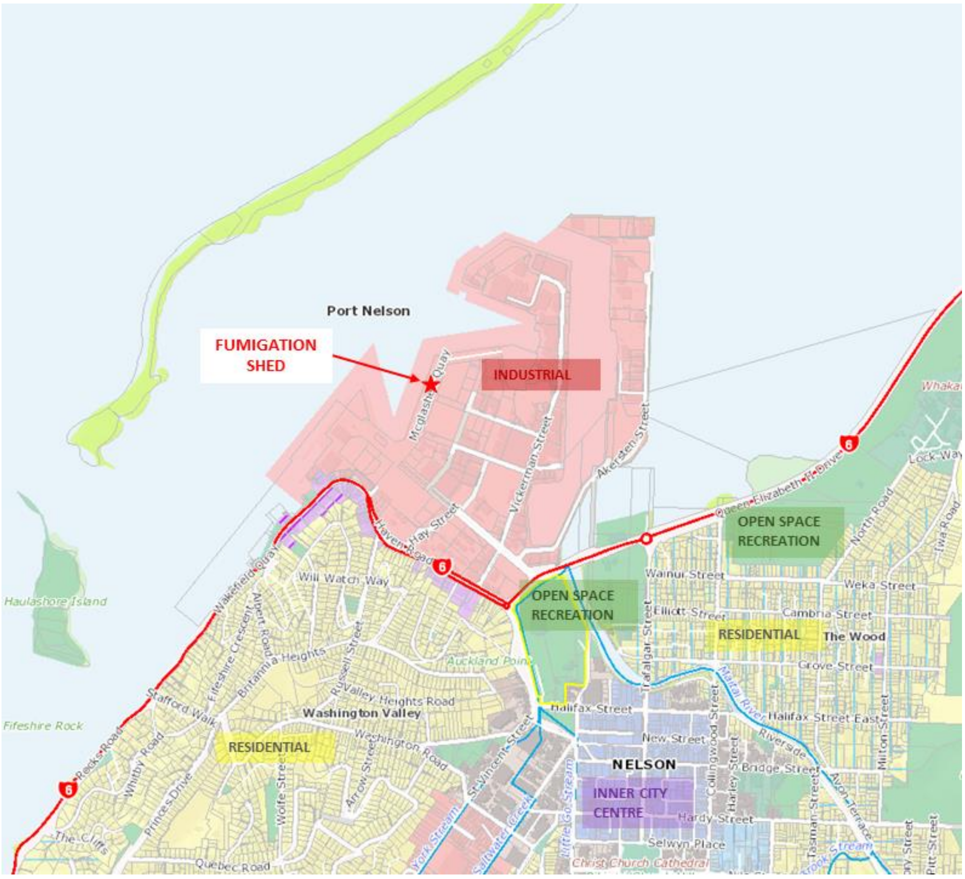


Figure 3-2. Location of the Fumigation shed (red star), and surrounding land use (Imagery sourced from Tasman District Council - Top of the South Maps)

3.3 Topography

The topography of the area can affect wind and airflow, and therefore the dispersion of contaminants emitted from the site. Elevated terrain in proximity to an emission source may lead to impingement of emission plumes at lower locations and a potential for lower concentrations than at higher elevations.

The topography of Port Nelson and the surrounding area is shown in Figure 3-3. Port Nelson and the area which immediately surrounds the port is comparatively flat. Similarly, the adjacent areas to the east of the port are also comparatively flat.

However, a ridge of hills is located to south of State Highway 6. These hills rise to the terrain elevation of approximately 60 m above sea level. This area is predominantly used for residential housing purposes. The hills run in the south-west direction along the coast and in a south-east direction toward central Nelson.

Another line of hills is located approximately 2 km to the east of the fumigation shed, and to the east of central city area, runs in a north-east direction.

Overall the topography of the area, and the coastal location of the site are expected to have a significant effect on air flows at the port.

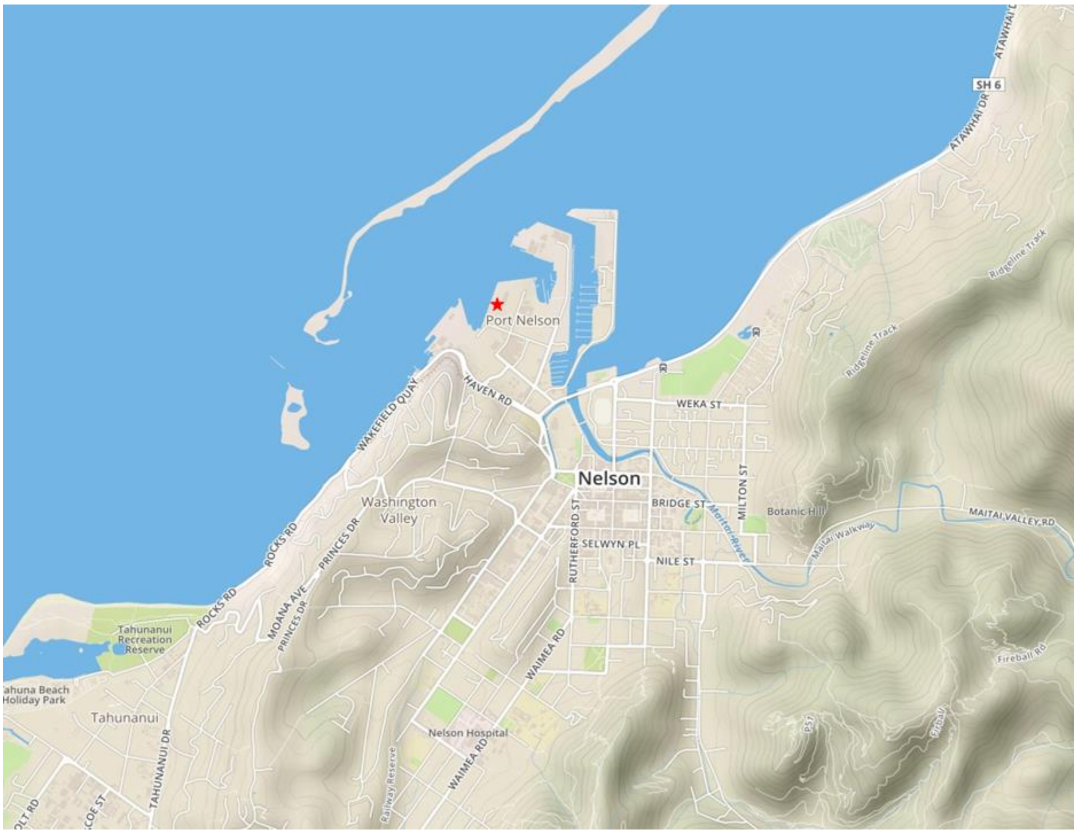


Figure 3-3. Topography of the town of Nelson (imagery sourced from LINZ Data Service)

3.4 Meteorological Conditions

Air pollutant levels are highly influenced by meteorological conditions. The most important of these parameters are wind speed, wind direction and the thermal stability of the atmosphere.

The topography of the area surrounding the shed is expected to have a significant effect on channelling local wind flows and the dispersion of any MB emitted from fumigation activities.

Drainage flows of the cooler denser air from the top of the hills toward of the port are likely to occur during cool stable night-time conditions. These drainage flows would tend to transport any emissions from the site in a north or north-west direction and therefore away from Nelson's residential areas and towards the ocean.

Land/sea breeze conditions can also expect to influence air flows at the port. Sea breezes during the day would tend to transport any emissions from the port in a southerly direction towards inland receptors, while land breezes at night would tend to transport emissions in a northerly direction towards the sea.

Port Nelson operates three meteorological monitoring stations at the port (i.e. the Main Wharf Station, Roro Station and Shed 7 Station). The distribution of wind speeds and wind directions measured at the monitoring stations for the year 2018 are shown in Figure 3-4. The wind roses have been superimposed on the aerial photograph of the port at the approximate location of the monitoring station. Similar wind flow distributions are observed for the years 2016 and 2017. These wind flow distributions are included in Appendix B of this report.

The wind roses show the predominant winds are from the south-southeast direction at the Roro and Shed 7 monitoring stations and from the south-east direction at the Main Wharf monitoring station. However, a secondary predominant wind flow from the north is observed at all three stations.

These distributions indicate that wind flows within the port can vary significantly over a comparatively short distance. The distribution shows the hills to the south of the site have a significant channelling effect on localised wind flows. These channelling effects are more complicated at the Main Wharf monitoring station as winds are channelled by the hills in both a south-west and south-east direction.

Higher average wind speeds (i.e. 3.93 m/s) are observed at the Main Wharf station compared to the Roro station (i.e. 3.75 m/s) and Shed 7 station (2.78 m/s). The higher average wind speeds reflect the more exposed location of this station, particularly in comparison to the Shed 7 station which is more sheltered from south westerly winds.

Figure 3-4. Wind speed and wind direction distribution at the Main Wharf Station, Roro Station and Shed 7 Station for the year 2018.

3.5 Background Air Quality

In order to assess the impacts of the emissions from the proposed plant on future air quality in the area, an estimate needs to be made of the current state of air quality at the site and in the surrounding area.

The primary source of MB is from industrial emissions. Beca understands there are no other industrial users of MB at the port or in the vicinity of the port. Emissions from the proposed fumigation activity are therefore expected to be the only contributor to ambient levels of MB at locations outside of the port boundary.

4 Air Quality Criteria

4.1 Ambient Air Quality Criteria Limits

Ambient contaminant concentration predictions may be compared with relevant criteria to assess the potential for adverse health and environmental effects to occur. The MfE *Good Practice Guide for Assessing Discharges to Air from Industry* (GPG Industry)[14] sets out the order of priority for the use of various air quality assessment criteria as follows:

- Air Quality Standards contained in the Resource Management (National Environmental Standards for Air Quality) Regulations 2004 (NESAQ)
- New Zealand Ambient Air Quality Guidelines (NZAAQG) published by MfE (2002)
- Regional air quality guidelines and standards
- World Health Organisation (WHO) guideline concentrations (where appropriate)
- International air quality criteria

There are no NESAQ air quality standards for MB. Similarly, there are also no NZAAQG or regional air quality guideline limits for MB.

The most relevant air quality criteria for MB are considered to be the Tolerable Exposure Limits (TELs) published by the Environmental Protection Authority (EPA) under the Hazardous Substances and New Organisms (HSNO) Act[15][16]. The TELs are designed for the protection of public health and represent concentration limits which should not be exceed at locations outside the fumigation buffer area at locations where the public may be exposed.

The TEL concentration limits are shown in Table 4-1. The 1-hour average TEL has been derived from the Californian OEHHA acute Reference Exposure Level (REL) for MB[17]. The 24-hour and annual average TELs are based on US EPA derived limits[18][19].

Table 4-1. EPA TELs for methyl bromide

Averaging period	Concentration Limit (ppm)	Concentration Limit (mg/m^3)
Annual	0.0013	0.005
24-hour	0.33	1.3
1-hour	1	3.9

[14] Ministry for the Environment, 2016, *"Good Practice Guide for Assessing Discharges to Air from Industry"*

[15] Environmental Protection Authority, 2011. *Methyl bromide fumigations Post-reassessment guidance for fumigators. April 2011*

[16] Environmental Risk Management Authority Decision: Application for the Reassessment of a Hazardous substance under Section 63 of the Hazardous Substances and New Organism Act 1996: Methyl Bromide formulated substances containing methyl bromide. Application Number: HRC08002. October 2010.

[17] OEHHA, 2008. *Appendix D.2 Acute RELs and toxicity summaries using the previous version of the Hot Spots Risk Assessment guidelines (OEHHA 1999)*

[18] US EPA, 2008. *Reregistration Eligibility Decision (RED) for Methyl Bromide*. U.S. Environmental Protection Agency, Office of Pesticide Programs, Health Effects Division (7509P). EPA 738-R-08-005.

[19] US EPA, 1992. *Bromomethane (CASRN 74-83-9)*. http://www.epa.gov/iris/subst/0015.htm

4.2 NAQP Rule AQr.4.1.2 Air Quality Criteria Conditions

The controlled activity fumigation Rule AQr.4.1.2 of the operative Nelson Air Plan specifies ambient air quality concentration limits as conditions. The relevant conditions of the rule are as follows.

a) *the concentration of methyl bromide from all discharges of methyl bromide occurring within the Port Security Area, including the combined discharges from permitted and controlled activities, does not exceed 3.9 mg/m^3 (calculated as a one-hour average) at any point on or beyond the landward boundary of the Port Security Area, and*

b) *the concentration of methyl bromide from all discharges of methyl bromide occurring within the Port Security Area resulting from controlled activities does not exceed 0.0025 mg/m^3 (calculated as an annual average) at any point on or beyond the landward boundary of the Port Security Area.*

The 1-hour MB concentration limit specified in condition a) of the rule is equivalent to the 1-hour average TEL. However, the annual MB concentration limit specified in condition b) of the rule is 50% of the annual average TEL.

The NAQP notes that compliance with Rule AQr.4.1.2 b) should be demonstrated using dispersion modelling methods.

5 Dispersion Modelling Methodology

5.1 Overview of the Modelling Methodology

The potential air quality effects of emissions of MB from the proposed fumigation activities were assessed using dispersion modelling techniques. The dispersion model CALPUFF was used to predict the maximum contribution the proposed discharges of MB would contribute to ambient air quality levels outside of Port Nelson. The ambient concentrations of MB predicted by the modelling were then compared to the relevant ambient air quality criteria to assess the potential for adverse health effects to occur.

5.2 Model Selection

The dispersion model CALPUFF (v7.2.1) was used for this assessment. CALPUFF is a non-steady-state puff dispersion model that simulates the three-dimensional effects of time and space-varying meteorological conditions on pollution transport. CALPUFF is recognised by the US EPA and the Ministry for the Environment (MfE) Good Practice Guide for Atmospheric Dispersion Modelling (**'GPG Modelling'**)[20], as an appropriate model in cases where contaminant dispersion will be influenced by complex terrain features and meteorological conditions. CALPUFF is increasingly used in New Zealand for regulatory assessment purposes in such instances.

The primary advantage of CALPUFF over simpler straight-line Gaussian dispersion models, such as AERMOD, is that meteorological conditions are modelled using a time-varying three-dimensional grid that is capable of simulating the effects that valleys, hills and land/sea interfaces can have on air flows. CALPUFF can also model the effect that changes in land use types have on atmospheric dispersion conditions. CALPUFF is generally considered to be a conservative dispersion model, tending to over-predict ground level contaminant concentrations.

CALPUFF is an appropriate model for this assessment as the local topography and coastal environment of the site is expected to have a significant effect on air flows and the dispersion of contaminants.

CALPUFF was run using the Lakes Environmental Ltd propriety graphical user interface software package 'CALPUFF View'.

5.3 Modelled Emission Scenarios

Two emission scenarios have been considered in the assessment.

Emission Scenario 1:

Emission scenario 1 has been used to predict the maximum annual average MB concentrations which could potentially occur outside the Port Security Area if the annual MB usage rate at the port is 4.3 t/year. Modelled emission rates assume the fumigation discharges occur evenly over the simulated meteorological year.

Emission Scenario 2:

Emission scenario 2 has been used to predict the maximum 1-hour average MB concentrations which could occur outside the Port Security Area. This scenario assumes peak emissions from the three recapture units and from the fumigation shed are occurring continuously for the 1-year simulation period. Emission rates are based on the maximum derived short-term emission rates. The predicted concentrations assume that peak concentration occur during worst case dispersion conditions.

[20] Ministry for the Environment, 2004. *Practice Guide for Atmospheric Dispersion Modelling*

5.4 Modelled Emission Sources

A summary of the modelled sources emission parameters is shown in Table 5-1 and Table 5-2. Discharges from the three MB recapture unit vents have been modelled as stack sources. The modelled discharge stack sources have been simulated in CALPUFF as having a 'zero vertical momentum flux' at the point of discharge to account for the horizontal discharge of the vents. A ventilation air flow rate of 1,000 m^3/hr is assumed for the recapture units.

The fumigation discharges of MB associated with the opening of shipping containers after ventilation have been modelled as three volume sources. The dimensions of each volume source are based on the dimensions of a standard shipping container door.

Desorption discharges from the fumigation shed have also been modelled as a volume source. The dimensions of the volume source are based on the dimensions of the fumigation shed. The fumigation shed is estimated to have a building height of 6 m, a length of 15 m and width of 13 m.

The modelled emission rates for Emission scenario 1 assumes the annual amount of MB emitted from the port is released evenly over the simulation period. The source emission rates are based on the estimated annual emission rates presented in Table 2-1 for the MB usage rate of 4.3 t/year.

The modelled emission rates for Emission scenario 2 assume that the maximum MB emission rate occurs continuously for the simulated meteorological year. Discharges from the three recapture units assume a constant MB discharge concentration of 5 ppm and a discharge rate of 0.0053 g/s (refer to section 0).

The fumigation shed emissions have been based on the derived maximum desorption rate of 0.0285 g/s (refer to section 2.3.3). The model assumes the rate of MB desorbed is the same as the rate that MB is emitted from the shed.

No fumigation discharges from the shipping containers are assumed for Emission scenario 2 as no container openings are expected to occur when three ventilations are in progress.

Table 5-1. Summary of modelled emission parameters for the three recapture unit ventilation discharges

Parameter	Recapture unit 1	Recapture unit 2	Recapture unit 3
Vent height	2.5 m	2.5 m	2.5m
Vent diameter (nominal)	0.2 m	0.2 m	0.2 m
Discharge velocity	8.84 m/s	8.84 m/s	8.84 m/s
Discharge temperature	15°C	15°C	15°C
Scenario 1 emission rate	1.636 kg/hr	1.636 kg/hr	1.636 kg/hr
Scenario 2 emission rate	0.019 kg/hr	0.019 kg/hr	0.019 kg/hr

Table 5-2. Summary of modelled emission parameters for the fugitive shipping containers and shed desorption discharges

Parameter	Container 1	Container 2	Container 3	Fumigation Shed
Release height	2.5 m	2.5 m	2.5m	3
Release width	0.2 m	0.2 m	0.2 m	14
Initial vertical spread	0.6 m	0.6 m	0.6 m	1.395 m
Initial horizontal spread	1.12 m	1.12 m	1.12 m	3.256 m
Scenario 1 emission rate	0.053 kg/hr	0.053 kg/hr	0.053 kg/hr	3.82 kg/hr
Scenario 2 emission rate	NA	NA	NA	0.1026 kg/hr

5.5 Meteorological Input File

Accurate atmospheric pollutant dispersion modelling requires good meteorological information that is representative of dispersion conditions near the emission sources, which is then processed into a format that can be used by the dispersion model. For this assessment, a 1-year CALMET meteorological modelling input file was used (corresponding to the year 2009). The meteorological input file was developed for the NCC.

Although there will be some variation from year to year, the construction of the CALMET file for the year 2009 is expected to be representative of typical dispersion conditions.

The CALMET input files define hourly meteorological conditions in a three-dimensional grid. Meteorological grid points are defined every 250 m in the north/south and east/west directions, and in 10 vertical layers. The meteorological grid covers a 26 km x 26 km area, which incorporates the proposed Nelson Port and the surrounding sensitive receptors.

The predicted hourly average wind speed and wind direction distribution at a height of 10 m above ground level, extracted from the CALMET meteorological input file at the fumigation shed, is shown in Figure 5-1. The windrose shows a predominance of winds from the southwest direction at the site, and secondary predominant wind flow from the northeast direction.

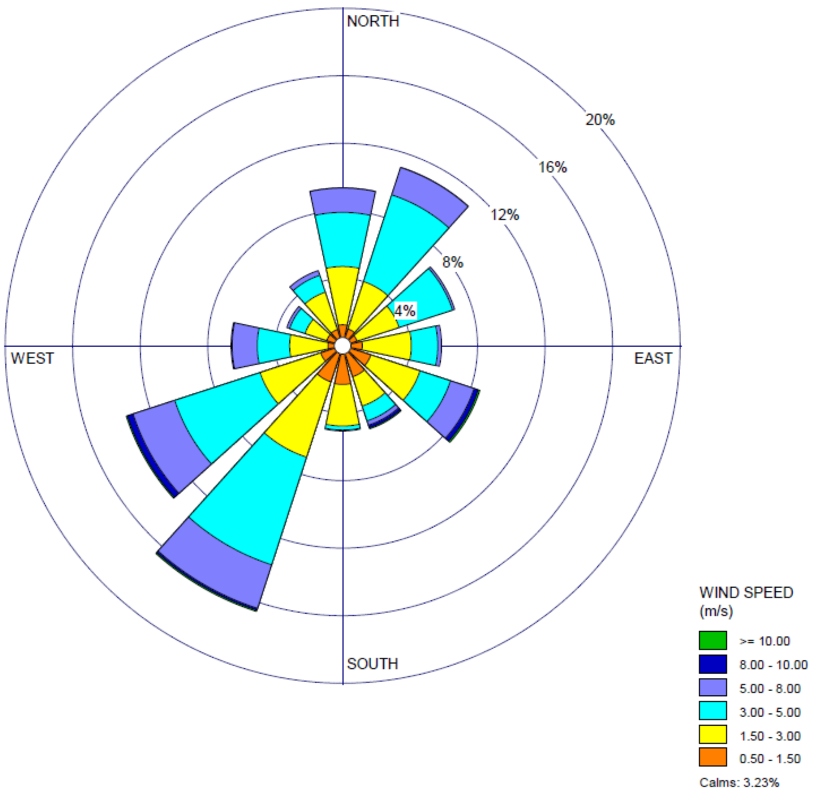


Figure 5-1. CALMET meteorological input file wind speed and wind direction distribution at Port Nelson

5.6 Terrain and Receptors

Terrain can have a significant influence on the dispersion of pollutants and predicted ground level concentrations. Terrain effects were incorporated into the dispersion model using a CALMET meteorological model grid and using CALPUFF's partial plume path adjustment method. The method reduces the effective height of the emission plume above ground level by up to 75%, as it travels over elevated terrain features.

As a consequence, higher concentrations are predicted for receptors located at elevated terrain features compared to receptors located on flat terrain.

In CALPUFF, receptor points were defined at 10 m interval in the north-south and east-west directions at within approximately 250 m of the secure fumigation area. An additional 2 discrete receptor points were defined at nearby residential dwellings located to the south of the port.

5.7 Other dispersion modelling parameters

Other CALPUFF dispersion modelling parameters selected for the assessment are;

- Dispersion coefficients computed from micrometeorological variables
- Transitional plume rise (Briggs)
- The PDF (probability density function) method used for sigma-z in the convective boundary layer

5.8 99.9 Percentile 1-hour Average Concentrations

The use of 99.9 percentile 1-hour averages is a standard dispersion modelling convention used to assess predicted pollutant 1-hour average concentrations. The 99.9 percentile 1-hour average concentration corresponds to the ninth highest 1-hour average concentrations predicted at each receptor point over the simulated meteorological year. The use of the 99.9 percentile 1-hour average is intended to filter out improbably high concentrations that may be predicted due to extreme meteorological events. The GPG for Dispersion Modelling advises that the predicted 99.9 percentile concentration is the maximum ground-level concentration that is likely to occur.

5.9 Building Downwash

Buildings and structures in the vicinity of a discharge can impact on airflow in the area and therefore the dispersion of contaminants within that discharge. This impact is referred to as building “downwash”. The effect of building downwash on the dispersion of MB emitted from the site has been incorporated into the dispersion model using the PRIME building wake algorithm. The PRIME algorithm is recommended by the MfE[21] as being the most appropriate method for simulating building “downwash”.

The model incorporated the building “downwash” effect of the fumigation shed and three (40ft) shipping containers which were assumed to be ventilated by the recapture unit.

21 Ministry for the Environment, 2004. *“Good Practice Guide for Atmospheric Dispersion Modelling.”*

6 Modelling Results

6.1 Predicted annual average methyl bromide concentrations

The predicted maximum annual average MB concentrations for the proposed fumigation activities assuming an annual MB usage rate of 4.3 t/year (i.e. Emission Scenario 1) is shown Table 6-1. The predicted annual average concentration contour plot for the emission scenario is provided in Appendix C.

The maximum annual average concentration outside the Port Security Area is predicted to be 0.07 µg/m^3 or 1.4 % of the annual TEL of 5 µg/m^3. The predicted maximum concentration is also 2.8 % of the air quality criteria limit of 2.5 µg/m^3 specified in the controlled activity Rule AQr.4.12 condition b.

The maximum annual concentration is predicted to occur at the boundary of the Port Security Area. At this location people would not be exposed to emissions of MB for any extended period.

At the most potentially impacted residential property, where people could reasonably be present day and night, the predicted annual; average MB concentration is 0.007 µg/m^3 or 0.14 % of the annual TEL of 5 µg/m^3.

These results indicate that discharges from the proposed fumigation activities will not result in an exceedance of the annual average TEL concentration limit.

Table 6-1. Predicted maximum annual average methyl bromide concentrations (µg/m^3) for Emission Scenario 1 assuming an annual MB usage rate of 4.3 t/year

Receptor	Predicted Maximum Annual Average Concentration (µg/m^3)
Maximum outside the Port Security Area	0.07
Maximum at any dwelling	0.007
Air quality criteria	**5 (TEL)** **2.5 (AQr.4.12 condition b)**

6.2 Predicted 1-hour average methyl bromide concentrations

The predicted maximum 99.9 percentile 1-hour average MB concentrations for the proposed fumigation activities (i.e. Emission Scenario 2) is shown in Table 6-2. Predicted concentrations assume maximum discharge conditions from ventilation and desorption activities occur continuously for the simulated period. It should be noted that the predicted concentrations are conservative and assume that maximum emission conditions occur simultaneously with worst-case dispersion conditions.

The predicted 99.9 percentile 1-hour average concentration contour plot for the emission scenario is provided in Appendix C.

The maximum 1-hour concentration outside the Port Security Area is predicted to be 70 µg/m^3 or 1.79 % of the 1-hour average TEL of 3,900 µg/m^3. The predicted maximum concentration is also 1.79 % of the air quality criteria limit of 3,900 µg/m^3 specified in the controlled activity Rule AQr.4.12 condition a.

The maximum 1-hour concentration is predicted to occur at the boundary of the Port Security Area. At the most impacted residential property, the predicted maximum 1-hour MB concentration is 10 µg/m^3 or 0.25 % of the 1-hour average TEL of 3,900 µg/m^3.

The results indicate that discharges from the proposed fumigation activities will not result in an exceedance of the 1-hour average TEL concentration limit.

The predicted maximum 1-hour average concentration outside the boundary is also 0.76 % of the 24-hour average TEL of 1,300 µg/m^3. The results also indicate that the 24-hour average TEL concentration limit would not be exceeded by the proposed discharges.

Table 6-2. Predicted maximum 99.9 percentile 1-hour methyl bromide concentrations (µg/m^3) for Emission Scenario 2

Receptor	Predicted Maximum 1-hour Average Concentration (µg/m^3)
Maximum outside the Port Security Area	70
Maximum at any dwelling	10
Air quality criteria	**3,900 (TEL)** **3,900 (AQr.4.12 condition a)**

7 Summary

Genera is proposing to continue to undertake fumigation activities at Port Nelson using the fumigant MB. Genera is proposing to use up 4.3 t/year of MB in fumigation activities. However, all fumigations will undergo MB recapture which minimises the discharge of MB to the atmosphere.

Small quantities of MB may be discharged to air during fumigation activities. The maximum amount of MB emitted is predicted to be less than 78 kg/yr.

The potential health effects of the proposed emissions have been assessed using the CALPUFF dispersion model and representative meteorological inputs. The model has been conservatively configured and predicted maximum ground level concentrations are expected to overestimate the contribution from the proposed fumigation actives to ambient pollutant levels.

The results of the modelling indicate that the discharges to air from the proposed fumigation activities would have a minimal effect on MB contaminant levels outside the Port Security Area and a negligible effect in the residential areas.

The modelling predictions indicate that maximum MB concentrations are not expected to exceed any relevant air quality criteria levels and any adverse effects on health will be less than minor.

Appendix A – Air Discharge Consent RM085422

RESOURCE CONSENT DECISION

Resource Consent number: RM085422

Pursuant to section 104 A of the Resource Management Act 1991 ("the Act"), the Nelson City Council ("the Council") hereby **grants** resource consent to:

Genera Limited

The activity to which this decision relates:

Discharge of methyl bromide gas to air

Location details:

Address of property: Port Security Area

Location co-ordinates: 2532627E 5993897N (New Zealand Map Grid Datum)

Duration of Consent

This consent expires in 10 years on 1 September 2020.

Meaning of words

AEE means the Assessment of Environmental Effects and is the document referred to in Condition 5(a) of this resource consent.

Application means all the documents listed in Condition 5 (a)–(c) of this resource consent.

Approved Handler means a person who holds a current test certificate certifying that the person has met the requirements of the *Hazardous Substances and New Organisms (Personnel Qualifications) Regulations 2001* in relation to an approved handler for methyl bromide.

Capture means the process of filtering the atmosphere within the fumigated volume to remove methyl bromide, and the detention of the methyl bromide on activated carbon filters.

Capture phase means the period of the fumigation when the atmosphere within the fumigated volume is being filtered by the capture system and methyl bromide is being removed and stored in the activated carbon.

Capture system means the technology described in section 3.1.3 of the AEE which filters methyl bromide from the fumigated volume during the capture phase.

Container means a shipping container.

Container fumigation means a fumigation being undertaken within a shipping container.

Destruction means rendering safe and disposing of captured methyl bromide.

Enclosed building means a shed, warehouse or similar building that can be completely closed to the elements during fumigation except for ventilation along the ridgeline, and where openings such as windows and doors have closures that are solid.

Fumigant means methyl bromide.

Fumigated volume means the volume contained within the fumigation enclosure (being a shipping container or within gas proof sheets).

Fumigation Manager means the person described in Condition 10 of this consent.

Fumigation means the use of a fumigant for the purpose of the destruction of rodents, pests, or other undesirable plant or animal organisms (Section 2, Fumigation Regulations 1967).

Advice note:

This resource consent authorises discharges to air from fumigation – i.e. from *the use of a fumigant* – only. The use of a fumigant means injection of the fumigant into a fumigated volume (i.e. fumigation under gas-proof sheets or inside containers), the capture phase, and ventilation of the fumigated volume only. *The use of a fumigant* does not include any discharges of captured fumigant that might occur from used activated carbon, either inside or outside of the Port Security Area.

Note also that fumigation must be carried out in accordance with Schedule 3, Sections 1–10, of the *Hazardous Substances (Fumigants) Transfer Notice 2004* (as amended 8 August 2006, or any subsequent amendment), pursuant to the Hazardous Substances and New Organisms Act 1996. Controls on fumigant use and discharges to air in Schedule 3 include the following:

- Licences are required for the use of methyl bromide (Section 1);
- Shipping containers under fumigation must not be moved (Section 2);
- Fumigation must not be carried out in areas where access can be gained by unauthorised persons or where the public may be lawfully present (Section 3);
- Shipping containers fumigated with methyl bromide must be gas tight and retain methyl bromide without leakage (Section 4);
- Fumigation cells fumigated with methyl bromide must be gas tight and retain methyl bromide without leakage (Section 5);
- Signs must be erected at every point of access where fumigation is being carried out, and for certain types of fumigation, at the perimeter of the risk area (Section 7); and
- Safety precautions must be adhered to (Section 9).

Fumigation under sheets and *fumigation under gas-proof sheets* means fumigation carried out where the fumigated volume is the contained under gas-proof sheets.

Gas-proof sheets are the tarpaulins described in section 3.2.2 of the AEE.

Port Security Area means the area identified on Plan A (attached).

Advice note:

The Port Security Area is owned and operated by Port Nelson Limited. At the date of the granting of this resource consent, the Port Security Area perimeter was located as shown on Plan A (attached). Note that any change made to the location of the perimeter may affect the potential locations for container and enclosed building fumigations (Conditions 14 and 19).

Recapture Unit means a capture system.

Recovery means removal and reprocessing of methyl bromide for reuse in a future fumigation.

Ventilation and *ventilating* means, in the case of fumigation inside an enclosed building, the discharge of air from within the fumigated volume to the ambient air, immediately following the end of the capture phase and either (i) via stacks, or (ii) when the gas-proof sheets are removed. In the case of fumigation inside a container, the v*entilation* and *ventilating* means opening the container door to the ambient air.

CONDITIONS

Pursuant to Section 108 of the Act, this consent is issued subject to the following conditions:

SCOPE OF THIS DISCHARGE PERMIT

1. The discharge to air authorised by this consent is of methyl bromide gas only, occurring exclusively from the process of fumigation, and therefore only under the following circumstances:

    a. in the case of fumigation inside containers: at the end of the capture phase. This means the discharge that occurs when the container is opened to the ambient air; and

    b. in the case of fumigation inside enclosed buildings: at the end of the capture phase. This means the discharge that occurs from ventilation and at the removal of the gas-proof sheets.

    This resource consent does not authorise discharges to air of methyl bromide or any other fumigant occurring from any other process, including but not limited to, passive discharges of methyl bromide from used activated carbon, or discharges to air caused by a recovery or destruction process.

SCHEDULE OF DOCUMENTS TO BE PROVIDED TO THE COUNCIL

2. *Emergency Management Plan*: A copy of the Consent Holder's Emergency Management Plan, covering all of the Consent Holder's operations at Port Nelson, shall be submitted to the Manager Resource Consents, Nelson City Council. In the first instance this submission shall be made within one month of the granting of this consent, and subsequently annually on or before 1 September and within 5 working days of any revision made to that document.

    The Emergency Management Plan shall be to the approval of the Manager Resource Consents, Nelson City Council.

    The Consent Holder shall comply with that Plan at all times during the period of this resource consent. A copy of the Emergency Management Plan, including associated instruction sheets, shall be available at all times at the gatehouse of the Port Security Area.

3. [Deleted]

    Advice note: Recovery of all methyl bromide from the activated carbon may avoid the need for disposal of waste activated carbon

Advice note: This resource consent does not authorise any discharge to air from a recovery process. Unless otherwise permitted by a rule in the Nelson Air Quality Plan, any such discharge would need to be authorised either by a separate resource consent or by a change to the conditions of this resource consent.

4. *Annual Report*: A copy of an Annual Report on the Consent Holder's fumigation activities at Port Nelson shall be forwarded the to the Manager Resource Consents, Nelson City Council, annually on or before 1 September and shall include, but not be limited to, summaries of data collected subject to Conditions 18 and 31 of this resource consent.

GENERAL CONDITIONS

5. The activity shall be carried out in accordance with the conditions of this resource consent and in accordance with the following documents:

    a. The document "GENERA LIMITED Port Nelson Methyl Bromide Fumigation Resource Consent Application and Assessment of Effects on the Environment" dated 17 December 2008 and prepared by Resource and Environmental Management Limited;

    b. Further information received from Genera Limited on 4 March 2009 (letter from Alan Perry, subject "Application Number 085422", dated 2 March 2009; and letter from Alan Perry, subject "Approval for Disposal in York Valley Landfill", dated 27 February 2009); and

    c. Further information received from Genera Limited on 16 April 2009 (Email from Alan Perry to Trevor Garnett, dated 15 April 2009, subject "Disposal of activated carbon contaminated with methyl bromide", incorporating an email from Eric Newport to Alan Perry, dated 15 April 2009).

    Where there is any apparent conflict between these documents and the conditions of this consent, the conditions shall prevail.

6. No less than 12 hours prior to commencing any fumigation, written notification of that fumigation shall be given to Port Security Office. The notification shall include the weight of methyl bromide to be used in the fumigation, the date and time when the fumigation will commence, the date and time that capture phase is expected to start, and the date and time when the opening of the container or ventilation and the removal of the gas-proof sheets is expected to occur.

    The notification shall also state whether:

    a. The fumigation will be inside an enclosed building, in which case the building shall be named; or

    b. The fumigation is to occur inside a shipping container, in which case the serial number of the container and its location at the time of the fumigation shall be given.

7. The total quantity of methyl bromide used in fumigations carried out under gas-proof sheets shall not exceed 4.3 tonnes per year.

    Advice note: Pursuant to Conditions 18 and 31 (Records to be kept), the Consent Holder shall maintain an itemised record of each fumigation that includes the total quantity of methyl bromide used. In accordance with Condition 4 this record shall be included in the Annual Report and at shall be made available immediately to the Nelson City Council's Monitoring Officer on request.

8. The concentration of methyl bromide from all discharges of methyl bromide occurring under this resource consent shall not exceed 0.0025 mg/m^3 (calculated as an annual average) at any point on or beyond the landward boundary of the Port Security Area.

9. The concentration of methyl bromide from all the Consent Holder's discharges of methyl bromide occurring within the Port Security Area (including discharges under this consent and any permitted discharges), shall not exceed 3.9 mg/m^3 (calculated as a one hour average) at any point on or beyond the landward boundary of the Port Security Area.

   Advice Note:

   Fumigation must be carried out in accordance with Schedule 3, Sections 1–10, of the *Hazardous Substances (Fumigants) Transfer Notice 2004* (as amended 8 August 2006, or any subsequent amendment), pursuant to the Hazardous Substances and New Organisms Act 1996.

   Controls on fumigant use and discharges to air in Schedule 3 include the following: Licences are required for the use of methyl bromide (Section 1); Shipping containers under fumigation must not be moved (Section 2); Fumigation must not be carried out in areas where access can be gained by unauthorised persons or where the public may be lawfully present (Section 3); Shipping containers fumigated with methyl bromide must be gas tight and retain methyl bromide without leakage (Section 4); Fumigation cells fumigated with methyl bromide must be gas tight and retain methyl bromide without leakage (Section 5); Signs must be erected at every point of access where fumigation is being carried out, and for certain types of fumigation, at the perimeter of the risk area (Section 7); and safety precautions must be adhered to (Section 9).

PERSONNEL

10. The Consent Holder shall appoint a person to the position of *Fumigation Manager* or similar, who shall be the Council's first point of contact for any matter regarding the exercising of this resource consent and compliance with its conditions. The Consent Holder shall provide the Manager Resource Consents, Nelson City Council, with that person's name and contact details in writing no less than one month following the granting of this consent, and shall ensure that, in the event of personnel changes, the Council's Monitoring Officer is advised in writing within 14 days.

11. Only persons fully trained in the use of the capture equipment shall operate that equipment.

12. All personnel involved in fumigations shall be approved handlers and records of their training and qualifications shall be maintained by the Consent Holder.

13. The Consent Holder shall ensure that all employees or contractors carrying out activities under this consent understand the resource consent conditions, and the Emergency Management Plan.

FUMIGATION INSIDE SHIPPING CONTAINERS

Conditions 14–18 apply to fumigation occurring inside shipping containers only.

Fumigation Process

14. Fumigation shall be undertaken only within a shipping container that is located at least 50 m inside the landward perimeter of the Port Security Area and at least 50 m from any berthed passenger ship occupied by passengers.

    Advice note: This condition requires that the Consent Holder ensure, before fumigation begins, that passenger ships are not scheduled to berth within 50 m of the enclosed building until proposed fumigation is scheduled to have ended.

15. Methyl bromide in the air space of the fumigated volume shall be captured and either destroyed or recovered at the end of the fumigation.

16. The capture phase shall end, and ventilation begin, only when the concentration of methyl bromide in the air in the fumigated volume is 5 parts per million (ppm) or less.

Signage

17. Prominent signs shall be erected in accordance with *Hazardous Substances (Fumigants) Transfer Notice 2004*, Schedule 3, Clause 7 (or subsequent version of that document) and signs shall remain in place throughout the fumigation.

Records to be kept

18. The Consent Holder shall keep records of each container fumigation, including for each:

(a) The date and time the fumigation started and ended;

(b) The date and time the capture phase started and ended;

(c) The weight of methyl bromide discharged into the fumigated volume;

(d) The concentration of methyl bromide recorded by the probe in the Recapture Unit immediately before the container is opened;

(e) The date and time the container is opened;

(f) The name of the Approved Handler undertaking the fumigation; and

(g) The location and serial number of the container at the time of the fumigation.

All such records shall be made available to the Council Monitoring Officer on request.

FUMIGATION INSIDE ENCLOSED BUILDINGS

Conditions 19–32 apply to fumigation occurring inside enclosed buildings only.

Fumigation Process

19. Fumigation shall be undertaken only within an enclosed building that is at least 100 m inside the landward perimeter of the Port Security Area and no less than 100 m from any berthed passenger ship that is occupied by passengers.

    Advice note: This condition requires that the Consent Holder ensure, before fumigation begins, that passenger ships are not scheduled to berth within 100 m of the enclosed building until proposed fumigation is scheduled to have ended.

20. Any enclosed building used for fumigation shall be fitted with discharge flues not less than 13.5 m in height (above ground level) for ventilation and a ridge-line vent at not less than 9.1 m in height above ground level.

21. The total amount of methyl bromide used in any fumigation within the enclosed building shall not exceed 250 kg.

22. Fumigation shall occur under gas-proof sheets.

23. The average concentration of methyl bromide in the enclosed building shall not exceed 14 ppm (60 mg/m_3) when measured within the first hour of fumigation at not less than eight representative locations, 1 m above floor level.

24. The concentration of methyl bromide measured at 1 or more monitoring locations 0.75-1.5 m below the roof ridge-line vent in the building shall not exceed 14 ppm (60 mg/m_3) at any time.

25. Methyl bromide in the air space of the fumigated volume shall be captured and either destroyed or recovered at the end of the fumigation (except as provided for by Conditions 26 and 27).

26. Notwithstanding Condition 27, if ventilation of the fumigated volume(s) is to occur from discharge stacks, then ventilation shall not occur until the capture system has been operated and the total rate at which methyl bromide is removed from all fumigated volumes within the building that are to be ventilated is less than 2.2 g/sec.

27. Notwithstanding Condition 26, if ventilation of the fumigated volume(s) is to occur by the removal of the tarpaulins (i.e. ventilating directly to the atmosphere in the building), then ventilation shall not occur until the capture system has been operated and the total rate at which methyl bromide is removed from all fumigated volumes within the building that are to be ventilated is less than 1.0 g/sec.

28. The rate of methyl bromide removal from the fumigated volume in grams per second, described in Conditions 26 and 27, shall be calculated as described in definition A2-24C of the Nelson Air Quality Plan.

29. If Conditions 26 and 27 have been met but subsequently a period of more than 30 minutes elapses between:

    (a) stopping operation of the capture system and ventilating via the discharge stacks, or

(b) stopping operation of the capture system and opening a fumigated volume to the atmosphere, or

(c) stopping ventilating via the discharge stacks and opening a fumigated volume to the atmosphere,

then the capture system shall be operated again until the rate at which methyl bromide is removed from the fumigated volume is reduced below the rate stated in Conditions 26 and 27.

Signage

30. Prominent signs shall be erected in accordance with *Hazardous Substances (Fumigants) Transfer Notice 2004*, Schedule 3, Clause 7 (or subsequent version of that document) and signs shall remain in place throughout the fumigation.

Security

31. The enclosed building shall kept closed with all doors locked:

(a) during a fumigation; and

(b) [Deleted]

This condition does not apply during periods of loading products for fumigation and unloading following fumigation.

Records to be kept

32. The Consent Holder shall keep records of each enclosed building fumigation, including for each:

(a) The date and time the fumigation started and ended;

(b) The date and time the capture phase started and ended;

(c) The weight of methyl bromide discharged into the fumigated volume;

(d) The concentration of methyl bromide recorded by the probe in the Recapture Unit immediately before the gas proof sheets were removed;

(e) The methyl bromide removal rate in the fumigated volume immediately before the end of the capture phase;

(f) The date and time the gas-proof covers were removed;

(g) The name of the approved handler undertaking the fumigation;

(h) Monitoring results of methyl bromide concentrations in the air within the fumigation building:

i. As described in Condition 23; and

ii. As described in Condition 24.

(i) The volume of activated carbon used by the capture system;

(j) Details of any fault or incident such as leakage of fumigant from the gas-proof sheets or the capture and destruction/recovery equipment, or any malfunction of the equipment. Details shall include, but not be limited to:

i. the date, time and location of the fault, incident or leak;

ii. the wind speed and direction at the time and during any leak or other discharge of methyl bromide;

iii. an analysis of the fault, incident or leak; and

iv. a record of any corrective action undertaken or planned to avoid, remedy or mitigate any possible adverse effect of the fault, incident or leak.

(k) Details of any complaint received by the Consent Holder in relation to the fumigation including, but not limited to:

i. the date, time and location of the event the complainant describes;

ii. (ii) the wind speed and direction at that time;

iii. (iii) an analysis of any fault, incident, leak or other possible reason for the compliant; and

iv. (iv) a record of any corrective action undertaken or planned to avoid, remedy or mitigate the cause of the compliant.

All such records shall be made available to the Council Monitoring Officer on request.

CAPTURE, RECOVERY AND DESTRUCTION OF METHYL BROMIDE

Activated carbon supply and use

33. Records shall be kept of the:

(a) Purchase and supply of activated carbon, including the volume supplied and used in the same units as those required by Condition 37. These records shall be, as a minimum, in the form of receipts from the activated carbon supplier; and

(b) Storage of activated carbon contaminated with methyl bromide in the Port Security area, including, as a minimum, the date of storage, volume of activated carbon stored, location of storage, the containment used, and the planned and actual disposal date.

34. Activated carbon that is contaminated with methyl bromide shall, at all times, be stored within a gas-proof vessel that is within the Port Security Area. That vessel shall be identified with a sign or signs that comply with Conditions 17 and 30 of this consent. Signage shall be maintained in position at all times when the vessel is being used for the storage of activated carbon containing methyl bromide.

Disposal of untreated activated carbon contaminated with methyl bromide to landfill

35. [Deleted]

36. [Deleted]

37. [Deleted]

38. [Deleted]

Disposal of treated activated carbon contaminated with methyl bromide

39. [Deleted]

40. [Deleted]

Recovery of methyl bromide from activated carbon

41. If the Consent Holder intends to undertake recovery within the region of Nelson City, then a method for this process and an assessment of its environmental effects shall be forwarded to the Manager Resource Consents, Nelson City Council for their consideration.

42. Recovery of methyl bromide from activated carbon may only be undertaken within the region of Nelson City if the Consent Holder has received confirmation in writing from the Manager Resource Consents, Nelson City Council, that this may be undertaken.

    Advice note: The process of recovery may not be consistent with the conditions of this resource consent, in which case the Consent Holder may need to apply for a change to the conditions of this consent, or the party undertaking the recovery may need to apply to the Nelson City Council for a separate resource consent.

    Advice note: Any discharge of methyl bromide to the air, other than from processes at the Port Security Area summarised in Condition 1, is not authorised by this resource consent.

DISPOSAL OF WASTE PRODUCTS

43. The Consent Holder shall ensure that the fumigant is destroyed or recovered in a lawful manner. Evidence of lawful destruction or recovery of methyl bromide shall be made available to the Nelson City Council's Monitoring Officer within five working days of any written request.

MONITORING

44. So that monitoring can be carried out, the Consent Holder shall notify the Council's Monitoring Officer of the intention to fumigate. Each notification shall be given in writing and at least 12 hours prior to the start of the proposed fumigation.

    Advice note: Failure to comply with this condition would be a breach of the consent conditions and enforcement action may result.

REVIEW OF CONSENT CONDITIONS

45. For the purposes of, and pursuant to Section 128 of the Act, the Council reserves the right to review the conditions of this consent annually during the month of April for any of the following purposes:

(a) to deal with any adverse effect on the environment which may arise from the exercise of the consent and which it is appropriate to deal with at a later stage; or

(b) to require the Consent Holder to do something that would otherwise contravene section 15 of the Act or to adopt the best practicable option to remove or reduce any adverse effect on the environment; or

(c) if any rule in the Nelson Resource Management Plan becomes operative and sets rules relating to air quality, and in the Nelson City Council's opinion it is appropriate to review the conditions of the resource consent to enable the levels set by the rule to be met; or

(d) when a relevant national environmental standard has been made; or

(e) if the information made available to the Nelson City Council by the applicant for the consent for the purposes of the application contained inaccuracies which materially influenced the decision made on the application and the effects of the exercise of the consent are such that it is necessary to apply more appropriate conditions.

ADVICE NOTES

1. This is not a building consent, and the Consent Holder shall meet the requirements of Council with regard to all Building and Health Bylaws, Regulations and Acts.

2. This resource consent authorises only the activity described above. Any matters or activities not referred to in this consent or covered by the conditions above must either:

    (a) comply with all the criteria of a relevant permitted activity in the Nelson Resource Management Plan (NRMP); or

    (b) be allowed by the Resource Management Act 1991; or

    (c) be authorised by a separate resource consent.

3. The Consent Holder should note that this resource consent does not override any registered interest on the property title.

4. Monitoring: A monitoring charge of $100 has been included in your invoice, as conditions of consent requiring monitoring have been imposed. This charge covers the costs involved in the first hour of monitoring compliance with the consent conditions. Where additional monitoring costs are required to determine that conditions have been met, these will be charged as per the Council’s Fees and Charges policy in force at the time. Please contact the Council’s Monitoring Officer, phone (03) 546 0381, when work commences on this consent, so that monitoring can be carried out. Please quote the consent number, RM085422.

Appendix B – Port Nelson Windroses

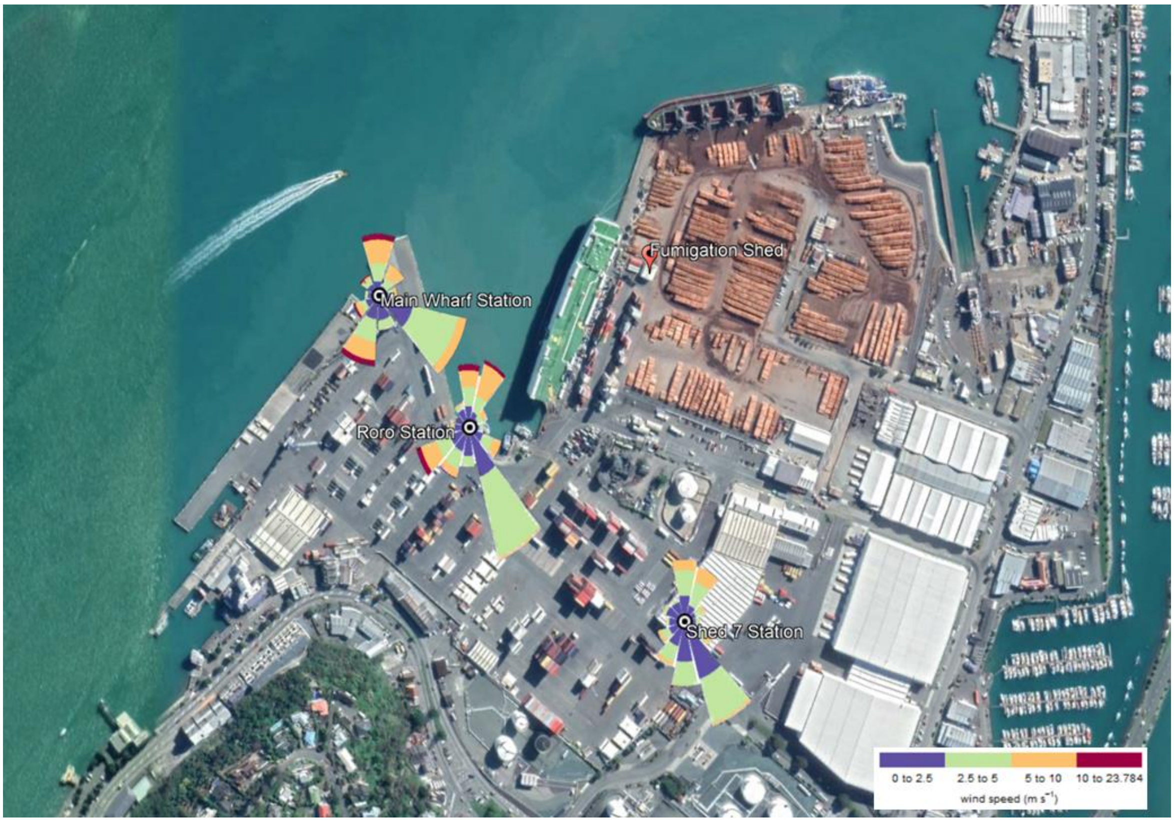


Figure B-1. Windroses (2016) for Port Nelson (wind data sourced by Genera, Imagery from GoogleEarth – 2019 Maxar Technologies)

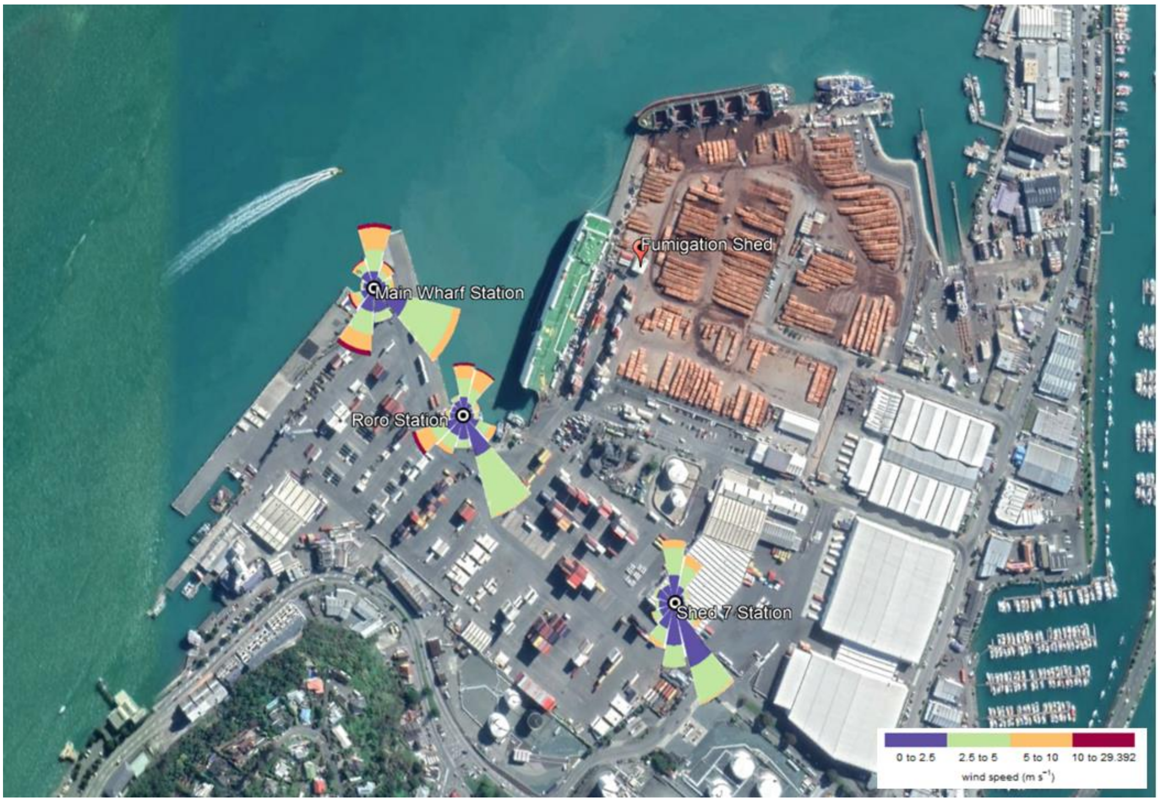


Figure B-2. Windroses (2017) for Port Nelson (wind data sourced by Genera, Imagery from GoogleEarth – 2019 Maxar Technologies)

Appendix C – Predicted Concentration Contour Plots

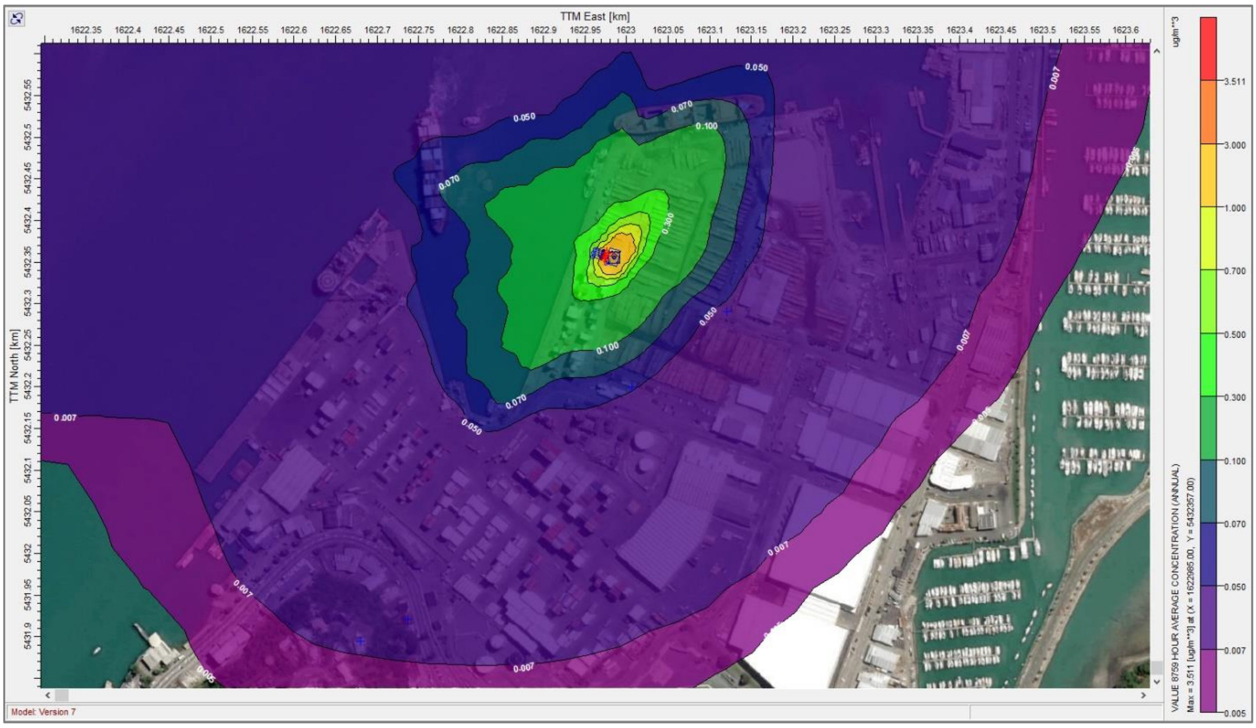


Figure C-3. Predicted annual average methyl bromide concentrations (µg/m^3) for Emission Scenario 1

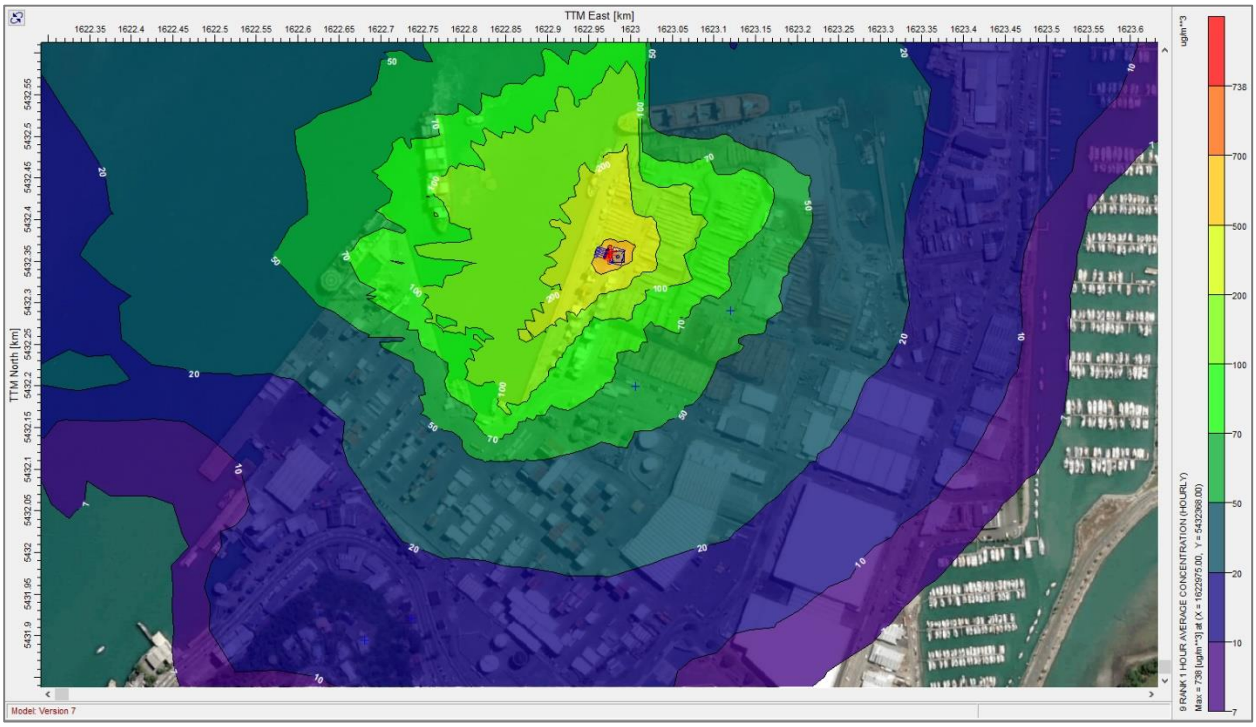


Figure C-4. Predicted 99.9 percentile 1-hour average methyl bromide concentrations (µg/m^3) for Emission Scenario 2

Appendix D – Nelson Air Plan Rule AQr41.2

AQr.41.2

The discharge of methyl bromide to air from fumigation within the Port Security Area of Port Nelson is a controlled activity if:

a) the concentration of methyl bromide from all discharges of methyl bromide occurring within the Port Security Area, including the combined discharges from permitted and controlled activities, does not exceed 3.9 mg/m3 (calculated as a one hour average) at any point on or beyond the landward boundary of the Port Security Area, and

b) the concentration of methyl bromide from all discharges of methyl bromide occurring within the Port Security Area resulting from controlled activities does not exceed 0.0025 mg/m^3 (calculated as an annual average) at any point on or beyond the landward boundary of the Port Security Area, and

c) the fumigation takes place within a shipping container (other than fumigation within a shipping container pursuant to Rule AQr.41.1), and

   i) any shipping container used is at least 50 metres inside the landward perimeter of the Port Security Area and further than 50 metres from any berthed passenger ship occupied by passengers, and

   ii) the methyl bromide in the air space of the fumigated volume is captured and either destroyed or recovered at the end of the fumigation period, and

   iii) methyl bromide capture from the container operates until the concentration of methyl bromide in the air in the container is reduced to 5 ppmv or less before the container is opened to the atmosphere, and

   iv) at least 12 hours prior to ventilating any container to the atmosphere written notification is given to the Port Security Office of the amount of methyl bromide to be used in the fumigation, the number of containers to be ventilated, the hours when the fumigation will commence and when opening for ventilation is expected to occur, or

d) the fumigation takes place entirely within an enclosed building, and

   i) the enclosed building is at least 100 metres inside the landward perimeter of the Port Security Area and further than 100 metres from any berthed passenger ship occupied by passengers, and

   ii) the total amount of methyl bromide used in any fumigation within the building does not exceed 250 kg, and

   iii) the fumigation occurs under gas-proof sheets, and

   iv) the methyl bromide in the air space of the fumigated volume is captured and either destroyed or recovered at the end of the fumigation period, and

   v) the capture system is operated until the total rate at which methyl bromide is removed from all fumigated volumes within the building that are to be ventilated, as determined in accordance with definition A2-24C, has decreased to:

      a. less than 2.2 g/sec if the discharge from the fumigated volume(s) under covers is being ventilated to discharge stacks, or

      b. less than 1.0 g/sec if the fumigated volume(s) are being opened by the removal of the covers and ventilated directly to the atmosphere in the building, and

   vi) notwithstanding (v) above the ventilation discharge from the capture system(s) is allowed to discharge directly to the discharge stack or stacks (rather than being re-circulated into the air space of the fumigated volume) if the total rate of discharge to the stack or stacks at any time is less than 2.2 g/sec, and

   vii) if a period of more than 30 minutes elapses between:

      a. stopping the capture system and ventilating via the discharge stacks, or

      b. stopping the capture system and opening a fumigated volume to the atmosphere, or

      c. stopping ventilating via the discharge stacks and opening a fumigated volume to the atmosphere,

   then the capture system or ventilation to the discharge stacks shall be operated if necessary until the rate at which methyl bromide is removed from the fumigated volume is reduced below the rate stated in v) a or b as appropriate, and

   viii) the spatial average of concentrations of methyl bromide measured 1 metre above floor level within the first hour of fumigation inside the building at not less than eight representative locations, shall not exceed 14 ppm (60 mg/m^3), and

   ix) the concentrations of methyl bromide measured at 1 or more monitoring locations 0.75-1.5 m below the roof ridge line vent in the building shall not exceed 14 ppm (60 mg/m3) at any time, and

   x) at least 12 hours prior to opening a fumigation volume to the atmosphere or ventilating via discharge stacks written notification must be given to the Port Security Office of the amount of methyl bromide to be used in the fumigation, the hours when the fumigation will commence, and when opening or ventilation is expected to occur.

Control reserved over:

i) monitoring,
ii) keeping of records,
iii) duration of consent,
iv) review of conditions,
v) training requirements for operators,
vi) the operation of the fumigation process to minimise discharge of methyl bromide to the atmosphere and to control potential adverse effects on human health and ecosystems,
vii) methods to minimise leakage of fumigant,
viii) the time at which the fumigation, and any discharge including any ventilating to the atmosphere occurs,
ix) the circumstances when ventilation of methyl bromide to the discharge stacks may occur,
x) the configuration of the building in which the fumigation occurs, including but not limited to the number, dimensions and location of discharge stacks and roof ventilators and the need for and capacity of fans associated with these,
xi) the number of fumigations occurring,
xii) signage, notices and methods of excluding people.

Applications need not be notified, the written approval of affected persons will not be necessary, and notice of applications need not be served on any person.

Introduction

This document has been compiled to comply with the document provided by BECA, *Appendix 12; Protocol for Monitoring Under Sheets.* Its purpose is to demonstrate Genera's capacity to recapture methyl bromide (MeBr) from the head-space of an enclosed log row post fumigation and prior to venting.

Methodology

Sampling from the log rows was carried out in accordance with the above mentioned BECA document and summarized as follows;

- A calibrated Gas Chromatograph (GC) was used to analyze gas samples collected from under a tarpaulin, using a syringe, from six sampling points per log row, as shown in Figure 1. Sampling points A and F were located at the front of the row and were adjacent to the inlet and

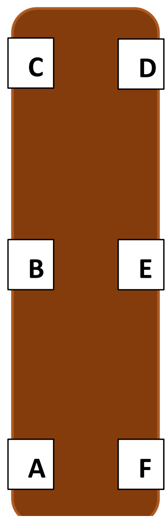


Figure 1 Sampling points around a log row.

  outlet of a recapture unit. These could vary from row to row so under each recapture the proximity of which sampling point is adjacent to what end of the recapture system is shown.
- A round of sampling was carried out every 20 minutes,
- Sampling was carried out until methyl bromide concentrations were below 20 percent of initial pre-recapture concentrations,
- Data relating to each log row monitored, meteorological conditions and subsequent venting were collated.
- Regarding 6.i. of the BECA document, which relates to 'freshness' of the scrubbing solution, this will be displayed as hours of use prior to each monitored recapture. Monitoring recapture with the GC is the most reliable way to determine volume of MeBr recaptured but is not always possible.

Recapture Results

Monitoring of the MeBr concentration under the tarpaulins will be shown graphically and as a percentage of initial readings in this section with field results shown in the Appendix. The appendix will show each sample as a peak area reading given by the GC and the average per sampling round will be shown in g/m^3. Each data point on the graphs represent the average of each sample round against the initial average.

Recapture 1 - Achieved

Recapture 1 was carried out successfully in terms of the 80% recapture efficiency target.

Recapture Data

Figure 2 shows the reduction of MeBr over time;

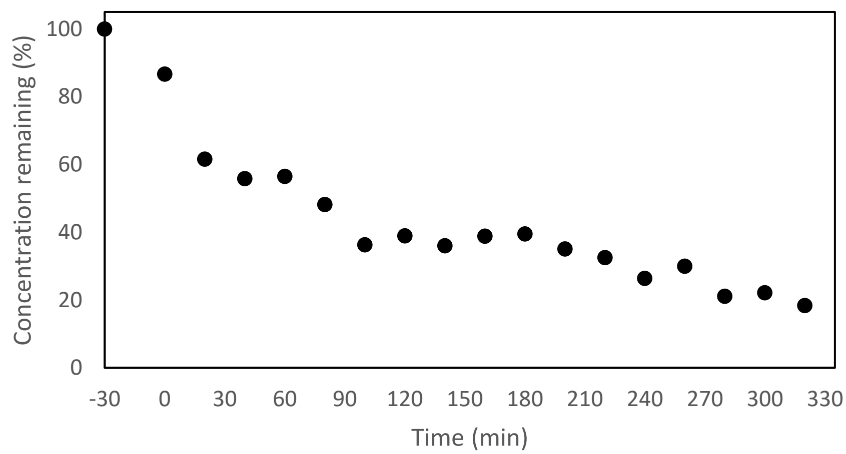


Figure 2 The reduction of MeBr over time during Recapture 1, based on percentage of initial MeBr concentration prior to recapture.

Table 1 shows the data relating to the log row and meteorological conditions at the time of recapture.

Table 1 Summary data of Recapture 1

Date	6/12/2019
Recapture start	9:35
Recapture finished	15:45
Log Row volume (m3)	677
Initial Riken (gm3)	187.6
Final Riken (gm3)	93.80
Recapture unit	2
Solution Usage (Hours)	1.7
Wind Speed (km/h)	9
Wind Direction	SSE
Temperature (^{o}C)	12.5
Relative Humidity (%)	82.9
Sampling Point A	Inlet
Sampling Point B	Outlet

Environmental Monitoring Data (Venting) and WES

Table 2 Environmental Monitoring data from venting including monitored row.

General Venting Information								WES	
Date	Number of rows	Recaptured Rows	MB usage (Kg)	Capacity (m3)	Wind (Direction/ Intensity) (knots)	Vent Start Time	Vent End Time	CUB ID	8 Hour Av. (ppm)
14.6.19	8	4/8	601	4977	SW/6	9:00	11:45	RA1	0.4785

Direct (TEL)				45 Degree Left (TEL)				45 Degree Right (TEL)			
CUB ID	1h Av. (ppm)	24h Av. (ppm)	Distance from closest Vent (m)	CUB ID	1h Av. (ppm)	24h Av. (ppm)	Distance from closest Vent (m)	CUB ID	1h Av. (ppm)	24h Av. (ppm)	Distance from closest Vent (m)
PB1	0.3475	0.0151	319	PB9	0.0800	0.0040	272	PB5	0.0733	0.0031	547

Recapture 2 - Constrained

Recapture 2 was unfortunately constrained by associated supply chain requirements. However, it to was heading towards being successful in terms of the 80% recapture efficiency target

The recapture event was cut short due to venting requirements of the row prior to nightfall. This was required so that the row, plus others around it, could be loaded onto a ship overnight.

Recapture Data

Figure 3 shows the reduction of MeBr over time;

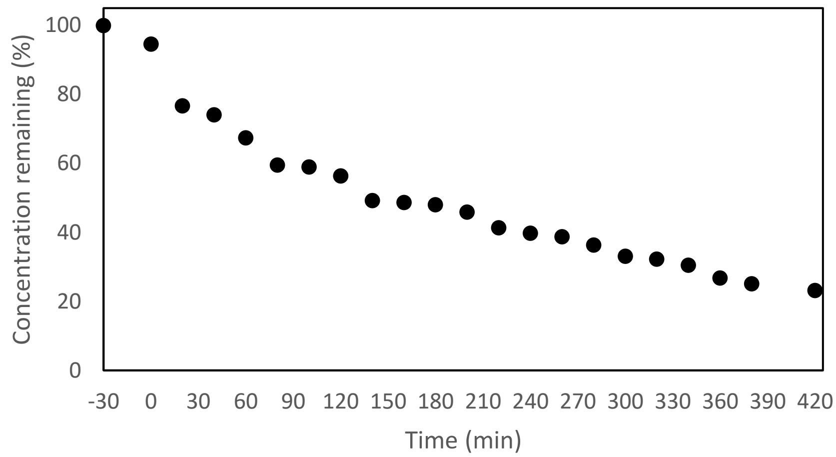


Figure 3 The reduction of MeBr over time during Recapture 2, based on percentage of initial MeBr concentration prior to recapture.

Table 3 shows the data relating to the log row and meteorological conditions at the time of recapture.

Table 3 Summary data of Recapture 2.

Date	6/13/2019
Recapture start	9:35
Recapture finished	17:25
Log Row volume (m3)	1188
Initial Riken (gm3)	200+
Final Riken (gm3)	101.50
Recapture unit	4
Solution Usage (Hours)	11
Wind Speed (km/h)	9
Wind Direction	SSE
Temperature (^{o}C)	12.5
Relative Humidity (%)	82.9
Sampling Point A	Inlet
Sampling Point B	Outlet

Environmental Monitoring Data (Venting) and WES

Table 4 Environmental Monitoring data from venting including monitored row.

General Venting Information								WES	
Date	Number of rows	Recaptured Rows	MB usage (Kg)	Capacity (m3)	Wind (Direction/ Intensity) (knots)	Vent Start Time	Vent End Time	CUB ID	8 Hour Av. (ppm)
13.6.19	19 rows	15/19	1955	16219	E/5	14:05	18:50	RA1	0.1371

Direct (TEL)				45 Degree Left (TEL)				45 Degree Right (TEL)			
CUB ID	1h Av. (ppm)	24h Av. (ppm)	Distance from closest Vent (m)	CUB ID	1h Av. (ppm)	24h Av. (ppm)	Distance from closest Vent (m)	CUB ID	1h Av. (ppm)	24h Av. (ppm)	Distance from closest Vent (m)
Offshore wind				PB3	0.1629	0.0103	1064	PB6	0.0619	0.0045	1599

Recapture 3 - Constrained

This monitoring was carried out between Recapture 2 sampling rounds and was initially delayed by a mechanical issue requiring an Engineer to rectify it. Samples were gathered from two locations once the issue was resolved. The locations chosen were based on previous trends in sampling, so the highest and lowest concentration points were selected to give an idea of concentration range across the row.

Recapture Data

Figure 4 shows the reduction of MeBr over time;

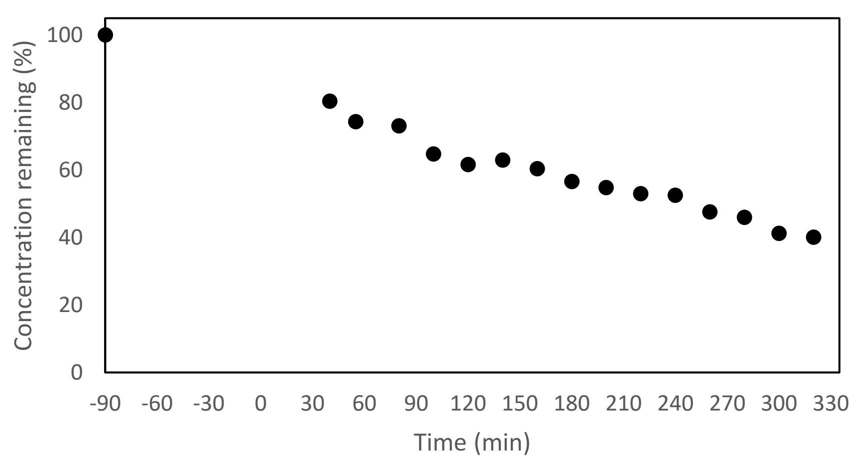


Figure 4 The reduction of MeBr over time during Recapture 3, based on percentage of initial MeBr concentration prior to recapture.

Table 3 shows the data relating to the log row and meteorological conditions at the time of recapture.

Table 5 Summary data of Recapture 3.

Date	6/13/2019
Recapture start	9:30
Recapture finished	16:40
Log Row volume (m3)	1577
Initial Riken (gm3)	200+
Final Riken (gm3)	126.51
Recapture unit	2
Solution Usage (Hours)	12.7
Wind Speed (km/h)	4
Wind Direction	W
Temperature (^{o}C)	17
Relative Humidity (%)	75
Sampling Point A	Outlet
Sampling Point B	Inlet

Environmental Monitoring Data (Venting) and WES

Please note that venting of Recaptures 2 and 3 were carried out in the same venting event.

Table 6 Environmental Monitoring data from venting including monitored row.

General Venting Information								WES	
Date	Number of rows	Recaptured Rows	MB usage (Kg)	Capacity (m3)	Wind (Direction/ Intensity) (knots)	Vent Start Time	Vent End Time	CUB ID	8 Hour Av. (ppm)
13.6.19	19 rows	15/19	1955	16219	E/5	14:05	18:50	RA1	0.1371

Direct (TEL)				45 Degree Left (TEL)				45 Degree Right (TEL)			
CUB ID	1h Av. (ppm)	24h Av. (ppm)	Distance from closest Vent (m)	CUB ID	1h Av. (ppm)	24h Av. (ppm)	Distance from closest Vent (m)	CUB ID	1h Av. (ppm)	24h Av. (ppm)	Distance from closest Vent (m)
		Offshore wind		PB3	0.1629	0.0103	1064	PB6	0.0619	0.0045	1599

Discussion

The aim of this recapture monitoring was to gather MeBr concentration data across 10 log rows within 3 days and demonstrate Genera's liquid scrubbing systems capability to recapture MeBr from the head space of an enclosed log row post-fumigation and pre-venting. As shown in the Recapture Results section above, one row reached the target, one would have got there and the fate of the third is uncertain. The key issues that constrained the sampling operation included early supply chain requirements for the cargo and engineering issues related to the machine.

To further compound the issue, getting 3 consecutive days of recapture monitoring during this period was problematic. This was primarily due to reduced cargo availability in what has been a quiet month. The team attempted to gather another days monitoring data, stretching the definition of 'a 3-day period' by attempting to carry out monitoring five days after the initial period, however, this monitoring was abandoned as the GC experienced technical issues that could not be resolved at the time.

Below is a list of issues confronted during the recapture monitoring process;

- Length of time the recapture process took to reduce MeBr concentrations to below 20 percent of initial concentrations,
- Number of sampling points per recaptured row,
- Amount of time rows available for recapture (external Operational pressures),
- Mechanical issues with recapture units,
- Operating issues with the GC,
- Location of recaptured rows (more urgency on Berth rows to be vented as opposed to the log yards),
- Appropriately skilled monitoring staff having other task-based pressures during the monitoring period.

Aligned with the intent of this learning focused task, the team have presented some suggested changes to the protocols. These suggestions are aimed at enabling effective monitoring of log rows in the future. The team from GSI (Genera Science and Innovation) are happy to discuss their findings in more detail.

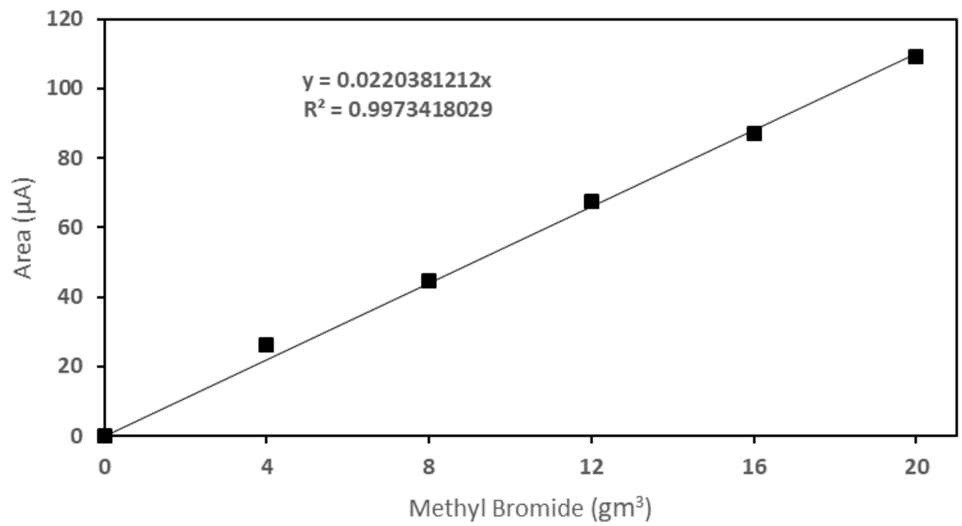
Table 7 Issues with points in the BECA document and possible solutions

Appendix 12 Ref.	Issue/s	Solution/s
1.	None	N/a
2.	None	N/a
3.	None	N/a
4.	• Number of samples per row • Two- to three-day monitoring period	• Reduce to 3 samples per row (front, middle, back) as concentrations follow a basic trend of low at the front, moderate in the middle and high at the end. This will allow for two rows to be monitored at a time, within the same 20-minute sampling period. • A five-day monitoring period to allow for Operational ebbs in recapture events. Data will still be representative as displayed by monitoring varying recapture units and scrubbing solution at varying stages of its operational life.
5.	None	N/a
6.	None, other than 6.i. • Defining 'freshness' of scrubbing solution	• Indicating MeBr volumes recaptured prior to monitored recapture event involves GC analysis of each row scrubbed for accurate results. As Genera does not monitor every recapture event with the GC the scrubbing solution is only tracked using an hour's meter on each recapture unit. Showing the usage hours based on the hours meter and the trends of the data itself will show the variability in solution 'freshness'.
7.	None	N/a

Appendix

Appendix 1: Gas Chromatograph Calibration Results

A 6-point (Including 0) calibration using dilutions of pure MB in air was performed at the beginning of the monitoring event to give a linear regression with an R2 of >0.992. Once successful standards were used on consecutive days to ensure the response from the GC was maintained. The use of the m and c figures from the y=mx+c equation given was used to convert GC – measured data (peak area) into ppm and g/m3.



Methyl Bromide (gm^3)	Std. 1	Std. 2	Std. 3	average
0	0	0	0	0
4	27.18	26.72	24.29	26.06
8	43.44	45.17	45.68	44.76
12	68.98	67.63	66.31	67.64
16	88.74	86.85	85.5	87.03
20	109.83	107.93	109.52	109.09

Appendix 2: Field Data

Below has the raw data for each recapture event. Data for each sample point is given as g/m^3 converted using the above formula from the peak area readings from the GC based on the calibration curve equation. The average converts each of the sample points into an average for each sampling round.

Recapture 1

Time	Duration (minutes)	A	B	C	D	E	F	Average (gm3)
9:35	-30	68.34	70.34	74.10	69.81	62.86	72.95	69.73
10:05	0	55.79	67.80	65.87	60.53	60.69	52.04	60.45
10:25	20	48.71	41.30	49.07	45.53	40.57	32.59	42.96
10:45	40	41.08	43.41	45.90	40.01	27.81	35.61	38.97
11:05	60	39.10	40.67	41.01	40.90	39.10	35.61	39.40
11:25	80	34.29	40.25	37.42	28.51	28.41	32.76	33.61
11:45	100	34.01	33.24	29.22	10.62	23.56	21.48	25.35
12:05	120	32.23	33.32	34.09	26.04	15.00	22.50	27.20
12:25	140	32.28	30.08	14.07	32.07	14.04	28.45	25.17
12:45	160	31.93	34.73	35.27	29.45	23.14	8.11	27.10
13:05	180	29.26	30.53	31.03	27.32	24.21	23.24	27.60
13:25	200	23.00	27.58	29.74	22.42	23.46	20.75	24.49
13:45	220	26.07	27.81	27.69	22.07	15.51	16.99	22.69
14:05	240	17.67	21.16	23.90	20.52	12.99	14.32	18.43
14:25	260	22.34	22.84	21.88	22.35	15.87	20.48	20.96
14:45	280	20.81	17.16	13.33	12.96	7.54	16.55	14.73
15:05	300	20.12	20.98	20.18	17.64	3.73	10.29	15.49
15:25	320	15.79	15.39	13.57	14.29	8.40	9.48	12.82

Recapture 2

Time	Duration (minutes)	A	B	C	D	E	F	Average (gm3)
9:35	-30	88.60	91.24	84.65	103.18	97.10	89.26	92.34
10:05	0	65.53	96.42	107.47	109.79	75.20	69.67	87.35
10:25	20	63.52	62.22	86.89	82.21	66.94	63.18	70.83
10:45	40	57.75	62.17	83.18	83.13	65.35	58.81	68.40
11:05	60	56.11	52.32	69.02	77.19	62.87	55.90	62.24
11:25	80	47.76	45.96	64.64	67.77	52.71	51.07	54.99
11:45	100	47.82	51.60	62.65	64.31	56.04	44.66	54.51
12:05	120	42.63	47.06	63.24	64.11	53.55	42.10	52.12
12:25	140	35.36	43.58	50.14	57.22	47.22	39.52	45.51
12:45	160	37.46	46.81	51.93	51.85	44.44	37.38	44.98
13:05	180	36.49	38.45	55.61	57.86	44.31	33.42	44.36
13:25	200	32.40	38.96	53.51	51.31	45.08	33.39	42.44
13:45	220	30.62	33.72	48.51	49.85	35.17	31.19	38.18
14:05	240	30.26	34.16	45.83	44.51	36.75	29.21	36.79
14:25	260	27.88	34.28	45.43	47.82	31.29	27.96	35.78
14:45	280	26.02	29.33	43.38	44.77	31.11	26.86	33.58
15:05	300	23.85	25.42	35.79	42.72	29.85	25.98	30.60
15:25	320	24.27	25.40	35.77	40.70	26.73	25.88	29.79
15:45	340	24.78	25.75	34.02	34.88	26.26	23.39	28.18
16:05	360	22.08	22.98	28.95	28.84	23.63	22.12	24.77
16:25	380	21.57	22.80	27.76	23.77	22.00	21.33	23.21
17:05	420	19.48	21.83	25.38	23.88	18.94	19.10	21.43

Recapture 3

Time	Duration (minutes)	A	B	C	D	E	F	Average (gm3)
9:30	-90	115.57	121.13	121.74	131.98	130.79	137.85	126.51
11:40	40	87.01			116.29			101.65
12:00	55	87.84			100.08			93.96
12:20	80	84.68			100.29			92.48
12:40	100	80.70			83.09			81.90
13:00	120	64.38			91.48			77.93
13:20	140	73.52			85.66			79.59
13:40	160	71.77			80.89			76.33
14:00	180	68.50			74.58			71.54
14:20	200	66.05			72.40			69.23
14:40	220	64.25			69.72			66.98
15:00	240	62.12			70.66			66.39
15:20	260	57.42			62.86			60.14
15:40	280	55.75			60.57			58.16
16:00	300	52.00			52.18			52.09
16:20	320	50.38			50.99			50.69

16 January 2020

Keith Frentz
Technical Director
Beca
PO Box 903
Tauranga 3140

Dear Keith

GENERA RESOURCE CONSENT APPLICATION – BAY OF PLENTY REGIONAL COUNCIL QUESTIONS

Please find attached ESR's responses to the relevant questions.

Yours sincerely

Peter Cressey
Senior Scientist

Peer reviewed by

Matthew Ashworth
Senior Scientist

BAY OF PLENTY REGIONAL COUNCIL COMMENTS/QUESTIONS

The following are the aspects of the Bay of Plenty Regional Council (BOPRC) questions that refer to the ESR report CSC19013.

7. LIMITS/ESR ASSESSMENT
The ESR report provides a comprehensive assessment of the general toxicology associated with the use of Methyl Bromide as a fumigant. However, it is considered that it doesn't adequately provide for the development of air quality criteria that can be used for the air dispersion modelling to determine the extent of effects on the environment and people. Further, in this instance, the discharge of fumigants is proposed to be undertaken for a number of short-term duration events or varying sizes, concentrations and locations. As a result, it is considered that the key matter of consideration is the acute exposure, up to a maximum of 24-hour averaging times, of people (both workers on the port and people exposed beyond the port boundary (in particular the vulnerable such as infants and the elderly)).

a) **Please review the air quality criteria contained in the ESR assessment, to provide specific consideration for the short term nature of the fumigation activities and the unique characteristics of the Port of Tauranga site.**
Currently, it is considered that the ESR assessment draws some general conclusions with regard to exposure limits. However given the nature of the exposure, being intermittent short term high exposures, it is considered that further analysis is required to identify the appropriate exposure limits that are applicable in this instance for each of the different fumigants. Such an approach may be the identification of 24-hour, 60-minute and 10-minute exposure limits, although the analysis will require specific assessment of the criteria considered to be appropriate. This analysis is required for each of the fumigants proposed to be used. It is noted that the atmospheric dispersion modelling will require updating to reflect these values.

It is unclear why the application has identified Phosphine as having a 15-minute Short Term Exposure Limit and Methyl Bromide (and the other proposed fumigants) do not, especially given the very high concentration releases of Methyl Bromide at ventilation from both ship holds and log piles.

b) **Please clarify if the application is seeking to impose a STEL on all fumigants. Additionally, please clarify the formula for determining the STEL in each instance and if the formula includes the use of models based on a distance approach. Note that the analysis required by a) above may address this matter.**

ESR RESPONSE

Question 7(a)

It should be noted that the setting of exposure limits or standards is generally a regulatory activity and, accordingly, the ESR analysis focussed on review of existing relevant regulatory activities, rather than the proposal of novel exposure limits. BOPRC has asked that 24-hour, 60-minute (1-hour) and 10-minute exposure limits be proposed for each of the fumigants considered.

<u>Methyl bromide</u>

24-hour (1.3 mg/m^3) and 1-hour (3.9 mg/m^3) tolerable exposure limits (TELs) for methyl bromide have already been established by the New Zealand Environmental Protection Authority (ERMA, 2009). These exposure limits have regulatory status in New Zealand and, as discussed in the ESR report, are more conservative than exposure limits proposed by some other authorities.

The 1-hour TEL (3.9 mg/m^3) was adopted from the California Environmental Protection Agency (CEPA, 2008) and is based on a study of methyl bromide exposed workers (Watrous, 1942). The CEPA assessment used the modified Haber's Law equation to extrapolate from a lowest observed adverse effect level (LOAEL) of 35 ppm for 2 hours exposure to a LOAEL of 59 ppm for a 1 hour exposure.

The modified Haber's Law equation is:

$$C^n \times t = k$$

Where *C* is the concentration of the toxicant, *t* is the exposure duration, *n* is a substance specific value and *k* is constant. CEPA used a value of $n = 1.33$ for methyl bromide. Using the same approach, the LOAEL for a 10-minute exposure would be 227 ppm. CEPA applied a total uncertainty factor of 60 (6x for extrapolation from a LOAEL to a NOAEL, 1x inter-species, 10x intra-species). On this basis a 10-minute TEL consistent with the current NZEPA 1-hour TEL would be 3.78 ppm or 15 mg/m^3.

While other bases for derivation of short-term exposure limits have been considered by other authorities, the 10-minute TEL derived here is consistent with current New Zealand regulation.

<u>Phosphine</u>

NZEPA has set a ceiling TEL for phosphine of 0.01 mg/m^3 (ERMA, 2006). A ceiling value is a concentration that should not be exceeded at any time. However, NZEPA did not establish duration-specific limits.

The US National Research Council Committee on Acute Exposure Guideline Levels (AEGL) concluded that data consistent with the definition of AEGL-1 values were not available for phosphine and AEGL-1 values were not derived. AEGL-1 is the airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic, non-sensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure. AEGL-1 values are usually derived for exposure durations of 10 and 30 minutes and 1, 4 and 8 hours.

CEPA derived an acute reference dose for phosphine of 0.05 ppm (0.07 mg/m^3), based on a NOAEL in a rat lethality study (CEPA, 2014). However, it was noted that the key study did not include testing for sub-lethal neurological effects. It should also be noted that the key study was not a true assessment of acute toxicity, with animals exposed for 6 hours/day, 5 days/week for 13 weeks.

Given the extremely steep dose-response relationship for phosphine, it is probably prudent to consider the NZEPA ceiling TEL as an appropriate exposure limit for all short-term exposure durations.

<u>Ethanedinitrile (EDN)</u>

NZEPA assessed EDN in 2018 (NZEPA, 2018). While NZEPA derived a TEL for long-term bystander exposure (0.034 ppm or 0.072 mg/m^3), short-term exposures was assessed against AEGL-1 values derived by the US National Research Council Committee on Acute Exposure Guideline Levels (NRC, 2014). For exposure durations of 10 minutes and 1 hour the AEGL-1 values were 2.5 and 2.0 ppm, respectively (5.3 and 4.3 mg/m^3 respectively). It should be noted that AEGL-1 values for hydrogen cyanide were adopted for EDN.

No appropriate derivation of a 24-hour exposure limit was found and there is a marked difference between the 8-hour AEGL-1 (1.0 ppm) and the NZEPA chronic TEL (0.034 ppm). Extrapolation from the 8-hour AEGL-1 to a 24-hour limit using the modified Haber's Law equation and a default value of $n = 1$, results in an estimate for a 24-hour TEL of 0.3 ppm (0.6 mg/m^3). However, it is not recommended that this TEL be applied without toxicological review.

Question 7(b)

As stated previously, it was not the intent of the ESR report to propose or impose exposure limits or standard, but to report what limits were in place and, if possible, what the bases for the limits were. It is likely that phosphine was assigned a WES-STEL due to its extreme acute toxicity, although the reason for the WES-STEL is not stated in the relevant WorkSafe publication.

It is considered that this question has been addressed under the previous section. It should be reiterated that the setting of exposure limits is a responsibility of the regulator and the exposure limits outlined in the previous section should be considered as proposals only.

References

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ERMA. (2006) Environmental Risk Management Authority Decision HSR05035. Wellington: Environmental Risk Management Authority.

ERMA. (2009) Application for the Reassessment of a Hazardous Substance under Section 63 of the Hazardous Substances and New Organisms Act 1996, Name of substance: methyl bromide, Application Number: HRC08002. Wellington: Environmental Risk Management Authority.

NRC. (2014) Acute Exposure Guideline Levels for Selected Airborne Chemicals: Volume 17. Washington: National Research Council.

NZEPA. (2018) Science memo - APP202804 - EDN. Wellington: New Zealand Environmental Protection Authority.

Watrous RM. (1942) Methyl bromide - local and mild systemic toxic effects. Industrial Medicine; 11: 575-578.