MALAYSIAN STANDARD

MS 2546:2013

Methyl bromide fumigation - Requirements

ICS: 65.100

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Committee representation

The Industry Standards Committee on Chemicals and Materials (ISC B) under whose authority this Malaysian Standard was developed, comprises representatives from the following organisations:

Department of Agriculture
Department of Chemistry, Malaysia
Department of Standards Malaysia
Malaysian Association of Standards Users
Malaysian Ceramic Industry Group
Malaysian Institute of Chemistry
Malaysian Paint Manufacturers Association
Malaysian Pulp and Paper Manufacturer's Association
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Science and Technology Research Institute for Defence
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Universiti Sains Malaysia
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The Technical Committee on Pesticides and Agrochemicals which developed this Malaysian Standard consists of representatives from the following organisations:

Ancom Crop Care Sdn Bhd
Department of Agriculture
Department of Chemistry, Malaysia
Department of Environment
Malaysian Agricultural Research and Development Institute
Malaysian Association of Standards Users
Malaysian CropLife and Public Health Association
Malaysian Palm Oil Board
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Co-opted members:

Department of Agriculture
Ministry of Health Malaysia
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Foreword

This Malaysian Standard was developed by the Technical Committee on Pesticides and Agrochemicals under the authority of the Industry Standards Committee on Chemicals and Materials.

Compliance with a Malaysian Standard does not of itself confer immunity from legal obligations.

Methyl bromide fumigation - Requirements

1 Scope

This Malaysian Standard prescribes the requirements for methyl bromide fumigation practices for quarantine purposes.

2 Normative references

The following normative references are indispensable for the application of this standard. For dated references, only the edition cited applies. For undated references, the latest edition of the normative references (including any amendments) applies.

MS 479:2012, *The safe handling of agricultural pesticides - Code of recommended practice (First revision)*

3 Terms and definitions

For the purposes of this standard, the following terms and definitions apply.

3.1 air space

Empty space between, above or around a commodity to allow the fumigant access to the commodity to eradicate pests.

3.2 ambient temperature

Temperature of the air surrounding the fumigation enclosure.

3.3 commodity

The item or goods that are being exported or targeted for fumigation.

3.4 concentration

The amount of fumigant present at a certain point in the fumigation enclosure, usually expressed as grams per cubic metre (g/m^3).

3.5 consignment

Refers collectively to the commodity, any packing materials used and the mode of transport such as a freight container.

3.6 container

Standardised transportation units intended to be suitable for transporting a variety of commodities.

3.7 dosage

The calculated amount of fumigant applied to a fumigation enclosure, usually expressed as kilos or grams.

3.8 fumigant

A chemical, which at a particular temperature and pressure can exist in a gaseous state, and in sufficient concentration and time is lethal to insects and other pests.

3.9 fumigation chamber

A permanent chamber used for fumigation purposes that meets the standard pressure test requirements.

3.10 fumigation

Application of a fumigant to a fumigation enclosure to eradicate pests, which involves the establishment of an atmosphere containing a lethal gas in the pests' environment at a concentration high enough, and an exposure period long enough to kill the target insect.

3.11 fumigation enclosure

Any space or area designed to contain a fumigant for the purpose of fumigation. Examples include gas-tight containers, gas-proof sheets sealed to an impermeable floor with sand or water snakes, and purpose built structures.

3.12 fumigator

A trained individual licensed to perform fumigation.

3.13 fumigation service provider

A company that is licensed to provide fumigation services and is registered with the relevant authority.

3.14 fumigation certificate

Documentation certifying that a fumigation treatment has been undertaken in compliance with the requirements of the relevant authority.

3.15 fumigation sheets

Gas impervious material (generally made from vinyl, coated nylon or polyethylene, also known as tarps or tarpaulins) capable of creating a temporary fumigation enclosure .

3.16 fumigant supply pipe

A relatively large diameter pipe used to supply fumigant to a fumigation enclosure.

3.17 gas equilibrium

At the start of fumigation, where the gas concentration at each monitoring point is within 15 % of the lowest reading. The relevant authority only accepts that a fumigation exposure has started after it has been demonstrated that equilibrium has been achieved and concentrations at all monitoring points are at or above the standard.

3.18 monitoring tube

A relatively small diameter tube used to withdraw a sample of gas/air mixture from within a fumigation enclosure for measuring fumigant concentration.

3.19 perishable commodities

Include cut flowers, fresh fruits, vegetables and nursery stock.

3.20 pests

Any species, strain or biotype of plant, animal or pathogenic agent injurious to plants and or animals and their products.

[MS 479: 2012]

3.21 phytotoxic

Poisonous to plants.

3.22 risk area

Any area in proximity to a fumigation enclosure into which fumigant may escape in hazardous concentrations as determined by local legislation. Relevant to fumigation practice in the location in which the treatment is performed. May also be referred to as ‘danger area’.

3.23 sand snake

Sand filled tubes approximately 1 m long used as weights to hold fumigation sheets in place during fumigation.

3.24 sheet fumigation

A process of creating a gas-tight enclosure by covering/enclosing the commodities to be fumigated under a gas proof sheet, which is sealed to an impermeable floor (generally using sand or water snakes).

3.25 sorption (sorptive)

The uptake of a fumigant by any material being treated with a fumigant. This may be reversible (unchanged fumigant may be released on ventilating) or irreversible (leading to residues of fumigant or its breakdown to by-products on the commodity).

3.26 threshold limit value (TLV)

TLV is the maximum concentration of fumigant that a worker can be repeatedly exposed to in the workplace without harmful effects. The TLV is 5 ppm and it is based on an 8 h per day for 5 days or 40 h per week.

3.27 timber (also known as lumber)

A commerce term for wood, either as logs or sawn units.

3.28 water snakes

Water filled tubes used as weights to seal fumigation sheets to the floor. They perform the same function as sand snakes. Water snakes are much longer and wider than sand snakes.

3.29 vapouriser

Equipment to convert liquid fumigant to gaseous state.

4 General and safety requirements

4.1 General requirement

4.1.1 Methyl bromide is an extremely toxic, colorless and odorless gas that is, at present, a widely used fumigant for quarantine purposes and soil fumigation. Methyl bromide fumigation has been used globally as disinfestation treatment for many years. It has a reputation for effectiveness against a wide range of pests and commodities. It is favored in many countries for plant quarantine because of its reputation for having:

a) good penetrating ability;

b) rapid action; and

c) high toxicity to a broad spectrum of insects and similar pests.

4.1.2 It is frequently used for treating timber, agricultural products, empty containers, foodstuffs, seeds and plants.

4.1.3 Methyl bromide fumigation is intended for preventing exotic pest incursions into Malaysia and for facilitating Malaysian exporters to meet the requirements of importing countries.

4.1.4 Methyl bromide fumigation is to be applied under strict discretion due to its ozone depleting property. Minimum effective application rates and avoidance of re-treatments should be observed through the availability of comprehensive and accurate information on treatment requirements (refer to Annex A on methyl bromide as an ozone depleting gas).

4.1.5 The fumigation site shall be secured and a safety risk assessment shall be undertaken by the fumigator.

4.1.6 The fumigation enclosure and the surrounding area shall be made safe for unprotected personnel (see 4.4).

4.1.7 The fumigators shall be responsible for complying with any relevant legislation or safety codes applicable to the state, territory, country or area, when performing a fumigation treatment for quarantine purposes.

4.1.8 The fumigation service provider shall employ competent and licensed fumigators who consistently perform effective fumigations, in accordance to successful assessment as required by the relevant authority.

4.2 Fumigation equipments

The following is a list of equipments required for methyl bromide treatments.

4.2.1 Enclosure equipment

4.2.1.1 **Clips**, to hold sheets rolled around battens.

4.2.1.2 **Fans**, for gas circulation.

4.2.1.3 **Fumigation sheet repair material**, including glue.

4.2.1.4 **Fumigation sheets**, (minimum thickness of 0.2 mm, permeability of less than 0.02 grams per day per square meter).

4.2.1.5 **Heaters**, to raise the temperature inside treatment enclosures (if required)

4.2.1.6 **Measuring tape**, to calculate volume of enclosure.

4.2.1.7 **Plastic tape**, to make temporary repairs to fumigation sheets.

4.2.1.8 **Ropes**, (to hold sheets in place and prevent them flapping loose).

4.2.1.9 **Sand** or **water snakes**, for sealing enclosures.

4.2.1.10 **Sealing tapes**, to seal container ventilators.

4.2.1.11 **Battens** or **sand snakes**, for joining sheets.

4.2.2 Gas delivery equipment

4.2.2.1 **Gas**, is supplied as liquid under pressure in the cylinder.

4.2.2.2 **Dispenser** or **weighing scale**, to measure the amount of methyl bromide delivered to enclosure.

4.2.2.3 **Gas supply lines**, from cylinder to vapouriser and from vapouriser to enclosure.

4.2.2.4 **Vapouriser**, to convert liquid methyl bromide to gaseous state.

4.2.3 Equipments for monitoring gas concentrations

4.2.3.1 **Gas detection instruments**, suitable for methyl bromide at fumigation concentrations.

4.2.3.2 **Detector**, to detect any gas leak.

4.2.3.3 Gas sampling lines.

4.3 Personal protective equipment (PPE)

When handling fumigation, the following articles of clothing shall be worn:

4.3.1 Regular work clothes (long pants, sleeves) or **overall**.

4.3.2 Full-face respirators or self-contained breathing apparatus, shall be used when releasing fumigant and while working within the risk area after the fumigant has been released.

4.3.3 Safety shoes.

4.4 Safety requirement

4.4.1 Warning signs

Warning signs shall include name of fumigator, contact number, date and shall be placed around the fumigation site.

4.4.2 Danger area

The perimeter of the danger area for open area shall be barricaded at least 10 ft away from the fumigation enclosure. The perimeter of the danger area for enclosed area such as warehouses and godowns shall be barricaded at least 20 ft away from the fumigation enclosure.

5 Type of fumigation enclosures

All fumigations shall be conducted in gas-tight enclosures. Where it is not intended to enclose the commodity in gas-proof sheets, the gas-tightness of the enclosure shall be determined prior to the introduction of any fumigant.

5.1 Un-sheeted fumigation

Pressure testing shall be undertaken every time any container is fumigated without sheeting, whereby a pressure decay time from 200 Pa to 100 Pa for 10 s or more shall be achieved to ensure gas-tightness (see Annex B on pressure testing). Otherwise the containers shall be sheeted.

5.2 Sheet fumigation

5.2.1 All fumigation sheets shall be visually inspected for tears, holes and abrasions. These shall be repaired or the sheet replaced.

5.2.2 Sheets shall be positioned to create a gas-tight seal with the floor.

5.2.3 Floor sheet shall be used when the floor is unsuitable for fumigation e.g. uneven, crack, rough surface. Sand snakes or water snakes shall be placed around the enclosures to retain the gas concentration. Two rows of overlapping sand snakes shall be sealed side by side like brickwork (overlapping).

5.2.4 Criteria for sheet fumigation are as the following:

a) A gas-tight seal shall be made between the sheets and the floor using material such as loose heaped sand or sand or water snakes/flumes (chains and timber are unsuitable for sealing sheets).

b) Ropes or belts may assist in holding fumigation sheets in place, preventing them from flapping loose.

c) Corners and areas where ropes, cords or sampling lines emerge from between or under the sheets shall be tightly sealed.

d) Loose sheet on corners of stacks should be secured to prevent blowing out by the wind.

e) Sheets shall be positioned to avoid any sharp corners or objects that might damage them. This may require protection by covering problem areas with a suitable cushioning material.

f) Sheets shall be arranged so that there is at least 500 mm of sheet extending beyond the limit of the seal.

5.3 Chamber fumigation

Chamber fumigation refers to fumigation treatment carried out within a specifically designed chamber. Before performing any chamber fumigation the fumigator shall:

a) visually inspect the door seals of the chamber;

b) ensure that no damage is done to the chamber and that there are no objects coming between the chamber and the chamber door, impairing the seal; and

c) perform a pressure test on the chamber to ensure that it is gas-tight. The pressure decay value from 200 Pa to 100 Pa shall be more than 10 s.

6 Fumigation considerations

6.1 Risk assessment

Before commencing any fumigation process, a risk assessment shall be carried out in order to minimise any occupational safety and health (OSH) risks, to meet local regulations, to protect the local population and the environment, and to address potential adverse effects on the commodity being fumigated.

6.2 Fumigation site

6.2.1 Site requirement

The fumigation site shall:

a) be isolated from unprotected personnel;

b) be well ventilated;

c) be sheltered from high winds (as much as possible);

d) have a smooth gas impervious floor; and

e) have a power supply available (either mains or generator).

6.2.2 Site floor

The fumigation site floor shall be impermeable to the fumigant if fumigation under gas proof sheets is to be carried out.

The floor of any site used for sheet fumigation shall be:

a) flat and free of stones and other sharp objects so that a gas-tight seal can be made between the sheets and the floor; and

b) free of cracks (including unsealed expansion joints in concrete floors) and drains or any other openings that will reduce the gas-tightness of the enclosure.

Where unsealed cracks or drains are present, they shall be no closer than 1 m from the fumigation enclosure.

6.3 Type of commodity

6.3.1 Non perishable

The commodity should be suitable for methyl bromide fumigation. Some commodities are unsuited to this treatment as they absorb large quantities of methyl bromide e.g oils, fats and finely ground materials. This may cause tainting or phyto-toxicity and may lead to hazards such as the presence of excessive bromide residues. This may result in the fumigated commodity not being suitable for its intended use.

If there is concern that a commodity may be adversely affected by methyl bromide, importers, exporters and fumigators should seek expert advice regarding its effects or conduct tests on the commodity.

See Annex C on commodities for which problems may occur when fumigated with methyl bromide.

6.3.2 Perishable

Perishable commodities include cut flowers, fresh fruits, vegetables and nursery stock. Fumigation of nursery stock and fresh flowers shall be performed according to the requirement set by the relevant authority.

6.4 Dosage and formulation

Fumigant dosage rates and the exposure time for a fumigation treatment will differ according to the nature of the goods being fumigated. Dosage rates will be stated on the Permit to Import issued by the relevant authority. It is the responsibility of the importer to obtain the correct dosage information from the authority. Some of the more common standard dosage rates are listed in Table 1.

Table 1. Common standard dosage rates for methyl bromide fumigation.

Pest/commodity	Dosage at normal air pressure (NAP)
Giant African snail (*Achatina spp.)*	128 g/m^3 at 21 °C for 24 h
Khapra beetle (*Trogoderma granarium)*	80 g/m^3 at 21 °C for 48 h with a minimum concentration of 32 g/m^3 after 24 h
Stored product pest	32g/m^3 at 21 °C for 24 h
Timber	48g/m^3 at 21 °C for 24 h

6.5 Temperature

6.5.1 Dosage compensation

The dosage shall be compensated for temperatures below 21 °C. For each 5 °C the temperature is expected to fall below 21 °C the fumigator shall add 8 g/m^3, unless otherwise specified by the authority. Dosage compensation is not applicable for temperatures above 21 °C. In such condition, the dosage shall be based on the recommended rate. Fumigation shall not be carried out below 10 °C. See Table 2 for examples of dosage adjustment according to the temperature.

Table 2. Examples of dosage adjustment according to the temperature

Temperature (°C)	Dosage (g/m^3)
21 and above (standard dosage)	32
16 to 20	40
11 to 15	48
10	56

6.5.2 Fumigation temperature for perishable

6.5.2.1 For quarantine purposes, the minimum acceptable temperature for fumigation of perishable commodities is 10 °C, unless specifically prescribed by the authority.

6.5.2.2 When temperatures are expected to be below 10 °C within the fumigation enclosure, some form of artificial heating shall be used. At temperature below 10 °C, the fumigant has decreased effectiveness against pests. An increased sorption of the gas will occur. Excessive fumigant uptake can pose an increased safety risk, as the gas is very difficult to be removed from inside the commodity.

6.5.2.3 Unless otherwise specified, the final concentration within the enclosure after fumigation of perishable commodities shall be at least 60 % of the original applied concentration.

6.5.2.4 Fumigation temperature of perishable commodities: Fresh fruit and vegetable

6.5.2.4.1 When fumigating fresh fruits and vegetables, the fruit pulp temperature shall be used for dosage calculations of methyl bromide. The minimum ambient temperature shall not be used for this purpose.

6.5.2.4.2 The fruit pulp temperature should be measured by placing the temperature probe into the centre of a fruit situated in the middle of (a minimum) three cartons sampling situated at the top, middle and bottom of a pallet. The lowest temperature recorded of the measured fruits will be the temperature used to calculate the dosage of methyl bromide for treatment purposes.

6.5.2.5 Fumigation temperature of perishable commodities: Live plant

6.5.2.5.1 Fumigation of nursery stock and fresh flowers shall not be conducted below 11 °C or above 30 °C.

6.5.2.5.2 Plants that have been refrigerated or stored in a cool room (below 11 °C) shall be brought up to ambient temperature of the enclosure prior to the introduction of methyl bromide.

6.5.2.5.3 Fumigation temperature at above 3 °C is likely to damage living plants.

6.5.2.5.4 Treatment of live plants including nursery stocks, cut flowers or seeds shall be carried in accordance with the prescribed procedures of the authority.

6.6 Circulation and penetration

6.6.1 Circulation

There shall be sufficient air space to circulate the fumigant and achieve uniform distribution throughout the enclosure. The fumigator shall be able to demonstrate that the required concentration of methyl bromide can reach the target of the fumigation by taking and recording concentration readings from representative points within the enclosure.

Timber shall be separated by a minimum of 5 mm of air space vertically for every 200 mm thickness of stacked timbers. The separators shall allow for any sagging timber to ensure that the 5 mm minimum separation is maintained along the entire length of the timber.

6.6.2 Penetration

6.6.2.1 Wrapping, surface and coating

The target of the fumigation shall not be wrapped in or coated with materials that are impervious to methyl bromide.

Goods covered with or packaged in gas impervious material such as plastic wrapping or laminated plastic films, lacquered or painted surfaces, aluminum foil, tarred or waxed paper shall have the coverings or packaging opened, cut or removed, prior to fumigation to allow adequate gas penetration into the consignment and subsequent airing, unless specifically exempted by the relevant authority.

Item with completely painted or lacquered surfaces shall be fumigated prior to painting or lacquering.

Owners shall make every effort to check the goods for impervious materials prior to fumigation. If the fumigator cannot either adequately assess the goods for impervious materials or adequately cut or open impervious materials, the fumigation shall not be carried out.

If the consignment has been checked and found suitable for fumigation, the fumigation certificate can be endorsed (refer to Annex D for example of fumigation certificate).

6.6.2.2 Timber and timber products

To ensure penetration, the acceptable timber and timber products for fumigation are:

a) if individual planks, rounds or articles have at least one physical dimension which is less than 200 mm (8 inch) thick;

b) if the consignment is vertically separated every 200 mm (8 inch); and

c) if there is adequate physical distance (at least 50 mm) between the timber and both the base and roof of the fumigation enclosure.

There is no specific horizontal distance for the separators however they shall maintain a continuous gap along the length of the timber. Methyl bromide will only penetrate 100 mm (4 inch) deep from a timber surface within the fumigation period. Gaps are important in facilitating adequate circulation of the fumigant around and throughout the consignment.

6.6.2.3 Arrangement of commodity/stacking

The air space requirements for effective treatment of a consignment will vary depending on the commodity and the method of packing. As a guide, there should be at least 350 mm of air space in total with 200 mm air space above the commodity, 50 mm below and the remaining 100 mm at the sides and between the commodity. Where commodities are stacked on the floor there shall be sufficient air space between individual items to allow the fumigant to act effectively on the target of the fumigation throughout the entire enclosure. If there is insufficient space to allow the monitoring tubes to be positioned according to the requirements then it is unlikely that the consignment can be fumigated effectively.

7 Preparing for fumigation enclosures

7.1 Monitoring tubes

7.1.1 All fumigations shall be monitored. For enclosures larger than 30 m^3 (equivalent to the average internal volume of a 20 ft shipping container), a minimum of three monitoring tubes shall be positioned within the enclosure.

7.1.2 For enclosures smaller than 30 m^3, a minimum of one monitoring tube shall be placed at the top centre of the commodity being fumigated.

7.1.3 For commodities not fumigated inside a container (e.g. large items of industrial and agricultural machinery, bagged grain, stacks of timber) the entire enclosed space within the fumigation sheets shall be treated as a single fumigation enclosure.

7.1.4 Monitoring tubes shall be placed as far as practicable from fumigant supply pipes.

a) One container shall have three monitoring tubes placed:

   i) one at the top back of the commodity - as far from the doors as possible;

   ii) one as close to the centre of the commodity as is practicable; and

   iii) one at the front base of the commodity.

b) Two containers (in one enclosure) shall have three monitoring tubes placed:

   i) one at the top centre of the commodity in each container; and

   ii) one at the front base of the commodity in either container.

c) Three containers or more (in one enclosure) shall have monitoring tubes placed:

   i) One at the top centre of each container.

7.1.5 All sampling/monitoring tubes shall be differentiated and identified by tagging or individually coloured tubes.

7.1.6 The monitoring tubes shall be crushproof nylon. The fumigators should ensure that:

a) a free flow of gas/air mixtures can be maintained;

b) no kinks or blockages are present in the hosing; and

c) the monitoring tubes are properly purged so the gas concentration inside the fumigation enclosure is correctly measured.

See Annex E for monitoring tube placement for container fumigation.

7.2 Fumigant supply lines (Introducing lines)

7.2.1 Supply lines shall be positioned to allow the fumigant to be introduced into the air space around the commodity.

7.2.2 Fumigant supply lines shall be placed at least 2 m from fumigant monitoring tubes.

7.2.3 To prevent leakage from supply lines:

a) gas-tight seal should be made around every supply line exit point from the enclosure; and

b) the exposed ends should be sealed after the fumigant has been introduced into the enclosure.

7.2.4 Where multiple fumigant supply line systems are used, the entire system shall be balanced in order to achieve even distribution throughout the enclosure. In order to balance the system, each arm of the system shall consist of fumigant supply lines that are equal in total length and diameter. See Annex F for gas supply pipe systems.

7.3 Delivery of the fumigant

7.3.1 Using a vapouriser or volatiliser

7.3.1.1 A vapouriser or volatiliser shall be used during all fumigations conducted. Even in warm or hot climates fumigators cannot rely on ambient temperatures alone to adequately vapourise liquid methyl bromide during the gassing process. Liquid methyl bromide has the potential to taint and damage certain products, such as seeds (loss of viability), aluminum (breakdown), foodstuff and other products and in some cases react with materials present in the enclosure.

7.3.1.2 The use of a vapouriser when introducing methyl bromide into the fumigation enclosure will ensure that the fumigant enters as a gas and is well distributed throughout the enclosure. Fumigant vapourisation ensures more effective distribution and penetration of the fumigant and reduces the possibility of product injury and pest survival.

7.3.1.3 The water in the vapouriser unit should be raised to the boiling point before any liquid methyl bromide is released through it. The water should be maintained at this temperature as far as possible throughout the gas introduction process.

7.3.1.4 In practice the temperature of the water in the vapouriser should not be allowed to fall below 65 °C to ensure complete vapourisation of the methyl bromide. The temperature can be monitored during the gas induction process by holding the gas introduction tube. The tube should feel warm/hot throughout the period in which the gas dosage is introduce into the fumigation enclosure.

7.3.1.5 If at any time the gas introduction tube becomes cold (less than 15 °C), the person conducting the fumigation should either:

a) stop the gas introduction process until the water in the vapouriser unit is at boiling point; or

b) reduce the gas introduction rate and allow the water in the vapouriser unit to return to the boil.

Diagrammatic instructions for constructing volatilising devices are included for information as in Annex G.

7.4 Fans

7.4.1 Fans shall be positioned to ensure that the fumigant is rapidly and effectively distributed throughout the fumigation enclosure.

7.4.2 For methyl bromide fumigation in small enclosures (such as freight containers), at least one fan shall be used. For fumigation in larger enclosures, at least two fans shall be used.

7.4.3 Where multiple containers are fumigated under the same sheets, fans shall be placed in each container.

7.4.4 The fans should be switched on 10 min to 15 min before the gas is introduced.

7.4.5 The fans should be switched off for monitoring about 30 min to 1 h after the gas introduction.

7.4.6 If equilibrium is not achieved, the fans should be switched on for another 10 min to 15 min and the monitoring shall be repeated.

7.4.7 Where high velocity and high volume fans are used, they should not run for longer than 15 min after the introduction of the gas, as they may force the fumigant out of the enclosure.

7.4.8 Fans should have a capacity to make at least 20 air changes an hour, taking into consideration the volume of the enclosure.

7.5 Sand and water snake specifications

7.5.1 When using sand snakes, a minimum of two rows of sand snakes shall be placed side by side with joins overlapping (like brickwork), and laid flush against the enclosure to create a continuous seal.

7.5.2 When using water snakes, a single, continuous water snake shall be laid flush against the enclosure to create a continuous seal.

7.5.3 Sand snakes shall be filled to only 65 % to 75 % with sand so that they lie flat on the fumigation floor.

7.5.4 Water snakes shall be filled to only 75 % to 85 % of capacity so that they lie flat on the fumigation floor.

7.5.5 Additional sand snakes may be placed on corners and other areas where fumigant leakage may be higher due to folds in the sheet or the presence of pipes or electrical leads. If water snakes are used, the sheets should be weighed down and sealed using a single, continuous water snake placed flush against the enclosure. Particular attention should be given to ensure a complete seal where the ends of the water snake meet. Water snake placement should not start or end on a corner.

8 Calculating fumigant dosage

8.1 Calculating fumigation enclosure volume

The volume of a fumigation enclosure should be calculated from the measured dimensions. When fumigating sheeted enclosures the measured external dimensions shall be used. Where an enclosed un-sheeted container or chamber is used for fumigation, the volume shall be inclusive of any external gas circulation equipment (e.g. blower and ducting). See Annex H for calculating the volume of fumigation enclosure of different shape.

NOTE. The volume of most freight containers is commonly written on the outside of the container, but this measurement can only be used if the container is not sheeted and has been satisfactorily pressure tested.

8.2 Calculating fumigant dosage

8.2.1 The dosage of methyl bromide applied to a fumigation enclosure should conform to the requirements of relevant authority for the commodity or country of import.

8.2.2 Compensation should be applied to the dosage for fumigant mixtures containing less than 100 % methyl bromide and for temperatures below 21 °C.

8.2.3 To calculate the dosage (weight) of methyl bromide to be introduced into the fumigation enclosure, the following formula should be applied:

$$D = V + C$$

where

D is the dosage, expressed in grams (g);

V is the volume, expressed in cubic metres (m^3); and

C is the required concentration, expressed in grams per cubic metre (g/m^3).

8.2.4 To calculate compensation for a mixture of 98 % methyl bromide and 2 % chloropicrin the following formula applies:

$$D = \frac{(V \times C)}{0.98}$$

9 Gas introduction and distribution

9.1 Using a vapouriser

9.1.1 A vapouriser shall be used for all fumigations conducted for quarantine purposes. Methyl bromide should be applied to the fumigation enclosure in gaseous form. It could be achieved by applying the liquid fumigant through a vapouriser (hot gassing) in order to fully volatilise the fumigant prior to its entry into the fumigation enclosure.

9.1.2 The water in the vapouriser unit should be raised to boiling point before any liquid methyl bromide is released through it. The water should be maintained at this temperature for as long as possible throughout the gas introduction process and should not be allowed to fall below 65 °C to ensure complete vapourisation of the methyl bromide (and chloropicrin if present).

NOTE. The temperature can be monitored during the gas introduction process by holding the gas supply pipe from the vapouriser to the fumigation enclosure. The pipe needs to be warmed/hot throughout the period in which the gas is introduced by keeping the heater on. If the temperature of the pipe reduces significantly, stop the introduction of the fumigant and allow the water in the vapouriser to re-boil, or slow the flow of the fumigant from the cylinder to the vapouriser. Complete fumigant vaporisation will allow more effective distribution and penetration of the fumigant, and will reduce the possibility of product damage and pest survival.

9.2 Distributing fumigant within the enclosures

9.2.1 Fans shall be operating during the application of the fumigant to ensure even distribution within the enclosure.

9.2.2 Effective distribution of methyl bromide shall be determined by monitoring gas concentrations at all monitoring points at set times after the introduction of the gas.

9.2.3 If all concentration levels cannot be achieved within 15 % of the lowest reading (equilibrium) the fumigant shall be redistributed by turning on the fan for a further period of time. Concentrations shall then be measured to see if all the readings are at or above the standard and equilibrium has been reached (refer Annex J for methyl bromide fumigation Ready Reckoner).

NOTE. This process has to be continued until either equilibrium is reached or when the levels drop below the standard. The fumigation cannot start if the fumigant levels drop below the standard concentration. If the cause can be identified and rectified without removing the sheet or losing excessive fumigant from the enclosure, the enclosure may be re-dosed and the fumigation process continued.

9.3 Checking for leaks

The fumigation enclosure and all application equipment shall be free from leaks. Checking for leaks shall be carried out during the fumigant introduction process and after all the fumigant has been applied to the enclosure at the start of fumigation. To check leak, a small amount of fumigant should be released through the system prior to the release of the total dose. All joins and connections shall be checked for leakage and corrective action taken, if required.

10 Monitoring fumigant concentrations

10.1 Monitoring frequency

10.1.1 Methyl bromide concentrations within the fumigation enclosure shall be measured on at least two occasions during the fumigation exposure period; at the start of the fumigation exposure period and at the end of the fumigation exposure period.

NOTE. The fumigation period begins when all the readings are at or above the standard concentration and equilibrium has been reached.

10.1.2 All instruments used for measuring and monitoring methyl bromide concentrations shall be fitted for the purpose, in good working order and calibrated on a regular basis according to manufacturer's instructions.

10.1.3 All instruments used for measuring and monitoring methyl bromide concentrations within a fumigation enclosure should be fitted with a moisture absorption filter, an appropriate carbon dioxide (CO_2) or other filter.

10.2 Fumigant levels

10.2.1 Fumigant concentrations shall be measured at the start and end of the fumigation exposure period.

10.2.1.1 Start-point monitoring

The fumigation exposure period begins when the methyl bromide concentrations at all monitoring points are at or above the standard and have reached equilibrium (when all readings are within 15 % of the lowest reading).

10.2.1.2 End-point monitoring

Methyl bromide concentrations at all monitoring points shall be at or above the standard at the end of the fumigation period, before fumigation can be declared successful.

10.2.2 Monitoring should be carried out as specified in Table 3.

Table 3. Monitoring times

Exposure period	Start-point monitoring	Mid-point monitoring	End-point monitoring
Less than 48 h	Take the first readings once it is reasonable to expect that equilibrium has been achieved.*	Not required but may be undertaken	End of exposure period
48 h or more	Take the first readings once it is reasonable to expect that equilibrium has been achieved.*	24 h after start and as required.	End of exposure period
* Equilibrium can be achieved quicker if: - There is good air space in the enclosure. - There are sufficient fans and they are positioned to best effect. - The methyl bromide is applied as a hot gas.			

NOTE. In addition to the monitoring times (Table 3) monitoring has to take place at intervals not greater than 6 h apart throughout the fumigation period if it is suspected that the relevant final concentration will not be achieved.

10.3 Fumigant concentrations

10.3.1 Fumigant concentrations shall be at or above the standard concentration (A) at all times, as set out in the Ready Reckoner (see Annex J). Some quarantine treatments require a higher retention rate than what is specified in this standard. In such cases the higher retention rate is the end-point concentration that shall be achieved for a successful fumigation. This is most common for fumigations of perishable commodities where there is a short exposure time.

10.3.2 The concentrations presented in the Ready Reckoner are based on the required percentage retention in Table 4.

Table 4. Standard concentrations required at specific monitoring times

Monitoring times (h)	Concentration of original fumigant required (%)
0.5	75 or more
1	70 or more
2	60 or more
4	50 or more
12	35 or more
24	30 or more
48	25 or more

10.4 Topping-up

10.4.1 Topping-up shall only be undertaken when fumigant concentrations are above the minimum top-up level at all monitoring points.

10.4.2 Topping-up is not an option for fumigations of less than 12 h.

10.4.3 When topping-up is done after the end point monitoring the exposure period shall be extended for a further 4 hours after which final monitoring readings shall be recorded and shall be at or above the standard.

10.4.4 The top-up dosage shall be applied in accordance with Annex K. Topping-up shall only be undertaken when fumigant concentrations are above the minimum concentration to allow top-up (B) in the methyl bromide fumigation Ready Reckoner at all monitoring points. Fumigant levels shall not be topped-up above the maximum top-up concentration (C) in the methyl bromide fumigation Ready Reckoner.

10.4.5 There are two options available for topping-up methyl bromide:

10.4.5.1 Option 1: Top-up-At end-point monitoring

This option allows for topping-up the level of methyl bromide at the end of the fumigation period, but only in certain circumstances and only if fumigant concentration levels have been monitored according to Table 4.

This option should be used if the fumigant concentration falls below the standard concentration (A) in the methyl bromide fumigation Ready Reckoner but not below the minimum concentration (C) in the methyl bromide fumigation Ready Reckoner. The fumigant levels may be topped up to not more than the maximum top-up concentration (B) in the methyl bromide fumigation Ready Reckoner.

10.4.5.2 Option 2: Top-up-Continuous monitoring with top-up options

This option should be used when highly sorptive commodities have to be fumigated and the need for a top-up is indicated.

NOTE. Commodities considered to be highly sorptive to methyl bromide include fish meals, bone meals, corn meals, nuts, seeds, fats, coffee beans and commodities packed in polystyrene material.

11 Completing the fumigation

11.1 Ventilation

11.1.1 On completion of a fumigation treatment, the fumigator shall ventilate the fumigant from the fumigation enclosure to below 5 ppm v/v (the current threshold limit value,TLV, for methyl bromide). This can be achieved either by natural airing or forced ventilation.

11.1.2 Ventilation of the enclosure shall be conducted so that the workplace threshold limit value (TLV) for methyl bromide is not exceeded outside of the risk area. If there is the likelihood of exceeding the TLV, then the risk area shall be extended beyond the recommended distance for the duration of the ventilation.

NOTE. The time taken to reach the TLV (5 ppm) may take longer than 48 h, particularly when:

a) commodities are fumigated in 40 ft (12.2 m) containers;

b) commodities are tightly packed or sorptive; and

c) free airspace around the commodity is less than a total of 350 mm.

Before measuring TLV, all fans being used for ventilation of the fumigation enclosure have to switch off. Where containers have been sheeted, the sheet has to be fully removed prior to testing for TLV. Where containers have been fumigated, fumigant concentrations have to be sampled from one or more representative points from within the fumigation enclosure. After taking the samples the fumigator will close the enclosure and leave the risk area. After 30 min of ventilation, the fumigator has to reopen the enclosure and check the fumigant concentration inside the enclosure. If the concentration is less than or equal to 5 ppm, the enclosure may be declared safe. If detected concentrations are above 5 ppm, the fumigator has to leave the risk area, re-ventilate using fans or naturally ventilate the enclosure for a further period of time and recommence the TLV check procedure. This process has to be repeated until all sections of the fumigation enclosure have been proved safe for re-entry.

11.1.3 Before anyone is allowed to access the fumigation enclosure, the fumigator has the responsibility to take precautions to ensure that the area is free from hazardous levels of fumigant.

11.1.4 Inadequate aerated goods could threaten the health of persons involved in their unpacking and inspection. Where there is no documentation showing that an enclosure has been ventilated, handlers should treat it as still ‘under gas’ until a qualified fumigator has cleared it as safe.

11.1.5 The equipment used for measuring methyl bromide concentrations in ‘risk areas’ and post treatment clearance of enclosures shall be fit for the purpose and capable of detecting concentrations of between 1 ppm to100 ppm.

11.2 Certification and release

Fumigation providers shall issue a certificate to indicate that the fumigation was successful and conformed to the requirement by the relevant authority (see Annex D). To support the claims made on the fumigation certificate, a record of fumigation (see Annex L) shall be completed on site and retained for audit purposes.

Annex A
(normative)

Methyl bromide as an ozone depleting gas

At a meeting of signatories to the Montreal Protocol in November 1992, methyl bromide was listed as a category I ozone depletant. This decision was made due to concern that methyl bromide's continued use would threaten the integrity of the ozone layer. This is a major environmental concern as the depletion of the ozone layer allows greater amounts of ultra violet (UV) radiation to reach the surface of the earth. Subsequently, developed countries have agreed to progressively phase out the general use of methyl bromide by the year 2005 and developing countries by 2015.

In recognition of the importance of methyl bromide as a quarantine tool, without alternatives in many cases, an international exemption on phase out for quarantine purpose has been agreed to for the time being. However, it is likely that as the phase-out takes effect the costs on producing methyl bromide will increase substantially, and the commodity may become increasingly difficult to obtain, as a result, and despite the current exemption, it is likely that methyl bromide has only a limiter future for quarantine purposes.

The relevant authority recognises the ozone depleting properties of methyl bromide and seeks to actively promote reduced methyl bromide use, within the constraints of quarantine protection, through:

a) encouraging effective use of treatments with this fumigant at minimum effective application rates;

b) advising its client industries of acceptable alternatives to methyl bromide where available; and

c) encouraging quality assurance practices that minimise reliance of end-point treatments as the primary measure to reduce quarantine risks associated with pest infestation in goods.

Suppliers and user of methyl bromide need to be aware that the import of this gas into Malaysia requires the approval from the relevant authority.

Annex B
(normative)

Pressure testing enclosures for gas-tightness

B.1 Inspection of empty containers

If a container can be selected prior to packing, the procedure below should be followed:

B.1.1 The container should be positioned to allow easy access to all four sides and the roof. It should stand on a flat, horizontal surface to avoid twisting (or racking) that may prevent the doors from providing an adequate seal.

B.1.2 The container should be examined before pressure testing to ensure it is structurally sound, the sides and roof are free of significant holes, and free of obvious distortion. Containers that are obviously damaged (e.g. where large holes and gaps are present in the roof and walls, or where the doors, door seals and locks do not fit and function properly) are not suitable and should not be pressure tested.

B.1.3 Where rust is present, the affected areas should be closely inspected and checked for the presence of holes. Containers with holes, gaps or those that are badly rusted are not suitable for pressure testing. The doors should make firm contact with each other, the doorframe and floor sill so that their seals function effectively. The rubber seals around the doors should be unbroken, leaving no obvious gaps. Containers with faulty doors and door seals are unsuitable for pressure testing.

B.1.4 The interior of the container should be examined from inside, with the doors closed so that any gaps or holes should be visible as they will allow light to enter the container. Containers with any holes and gaps are unsuitable for pressure testing. Containers with wet or damaged floors are not suitable for pressure testing. Dry floors that are in good condition showing no signs of damage are suitable for pressure testing.

B.2 Closing the ventilators

B.2.1 All ventilators should be sealed on the outside of the container.

B.2.2 The area around each ventilator should be dried and free from grease, then completely cover and seal all ventilators to make them gas-tight. The most effective way to seal ventilators is to completely cover them with plastic duct tape.

B.2.3 It is important to unseal all ventilators at the end of the exposure period and always before the container is loaded onto any form of transport.

B.3 Pressurising the container

B.3.1 This should be done without drilling holes through the walls of the container.

B.3.2 It is recommended that a 'finger manifold' be used for pressure testing (Figure B.1).

NOTE. The finger manifold is designed to deliver high pressure compressed air into a container, rapidly pressurise it and then allow the pressure decay time to be measured. The manifold has twelve 'fingers', nine of which deliver compressed air into the container while the other three measure the pressure within the container. The 'fingers' are made of soft copper tubing that can be bent to shape as necessary. The manifold is bent to fit over the front of the sill so that it can be sealed between the right hand door and the sill, and removed after the pressure test has been completed.

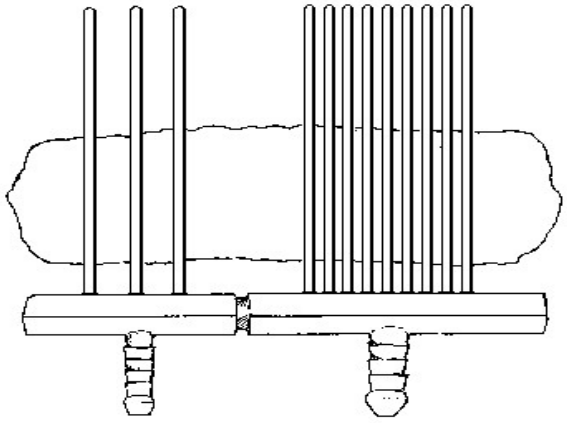


Figure B.1. Finger manifold for delivering high pressure compressed air into a container and measuring the pressure inside the container.

B.4 Instruments for measuring the pressure decay time

The pressure inside the container can be measured using a variety of instruments. The equipment required ranges from relatively simple to proprietary instruments including:

a) a simple U tube manometer or an inclined manometer, using a manually operated stop watch;

b) any sensitive pressure gauge, using a manually operated stop watch; and

c) a purpose made instrument, the contestor, which combines a pressure sensor with a timer that cuts in when the required pressures have been achieved.

B.5 Procedure for pressure testing

B.5.1 The area around the container ventilator should be dried and free from grease, then completely cover and seal all ventilators to make them gas-tight.

B.5.2 The pressure inside the closed container should be raised to 250 Pa using high-pressure compressed air supplied from a portable compressor or gas cylinders.

B.5.3 As the pressure inside the container reaches 250 Pa, the compressed air supply should be turned off.

B.5.4 The pressure should be allowed to decay to 200 Pa. Start measuring the time (in seconds) when it reaches 200 Pa and stop measuring the time (in seconds) when it reaches 100 Pa.

B.5.5 The pressure decay time should be recorded.

NOTE. The containers that give a pressure decay time from 200 Pa to 100 Pa of 10 s or more are considered as gas-tight. Such containers may be fumigated with methyl bromide without enclosing them under gas proof sheets. Where the pressure decay time does not meet the minimum requirements, the container has to be enclosed in gas proof sheets.

Annex C
(normative)

Commodities for which problems may occur when fumigated with methyl bromide

Commodity	Additional information
1 Foodstuffs: a) butter, lard and fats; b) iodised salt stabilised with sodium hyposulphite; c) full fat soybean flour, whole wheat flour, other high protein flours and baking powders; d) nuts with high oil content; e) certain baking sodas, cattle licks, salt blocks, or other foodstuffs containing reactive sulphur compounds; and f) bone meal.	Never exceed the recommended dosage or exposure periods for food or foodstuff commodities.
2 Leather goods	Particularly kid or other leather goods tanned with sulphur processes.
3 Woollens	Extreme caution should be used in the fumigation of Angora woollens. Some adverse effects have been noted on woollen socks, sweaters, shawls and yarn.
4 Viscose rayon	Rayons processed or manufactured with the use of carbon bisulfide.
5 Photographic chemicals	Excluding camera film or X-ray film.
6 Paper: a) silver polishing papers; b) certain writing and other papers cured by sulphide processes; c) photographic prints; d) “carbonless” carbon paper; and e) blueprint papers.	-
7 Rubber goods: a) sponge rubber; b) foam rubber, such as rug padding, pillows, cushions, mattresses, and some car seals; and c) rubber stamps and other similar forms of reclaimed rubber.	-
8 Vinyl	-
9 Furs	-
10 Feathers	Especially in feather pillows.
11 Rug padding	e.g. foam rubber, felts, etc.
12 Charcoal, cinder blocks and activated carbon	-
13 Horsehair articles	-
14 Oil artworks	-
15 Sulphur based paint	-
16 Cellophane	-
17 Polystyrene packaging and containers	Polystyrene can absorb large quantities of methyl bromide, which may take a long time to desorbs.

Annex D
(informative)

Example of a fumigation certificate

LETTERHEAD OF TREATMENT PROVIDER

A statement certifying:

"The goods described below were treated in accordance with the fumigation requirements of the …….(respective country requirements or relevant international standard)"

An additional declaration stating that:

"This consignment has been verified free of impervious surface/layer that may adversely affect the penetration of the fumigant, prior to fumigation"

Details of treatment

Name of fumigant …… Date of fumigation …….

Place of fumigation……

Dosage: Concentration …….. g/m^3 Exposure period ……..hours

Minimum ambient temperature during fumigation (or fruit pulp temp) ……^{O}C

Fumigation performed under gas-tight sheets Yes ☐ No ☐

If No, pressure decay (gas-tightness) value for 200 Pa – 100 Pa ……. seconds.

Description of goods

Container number (or numerical link) ……

Name of exporter ……Address ……..

Name of consignee ……Address …….

Type and description of cargo ……..

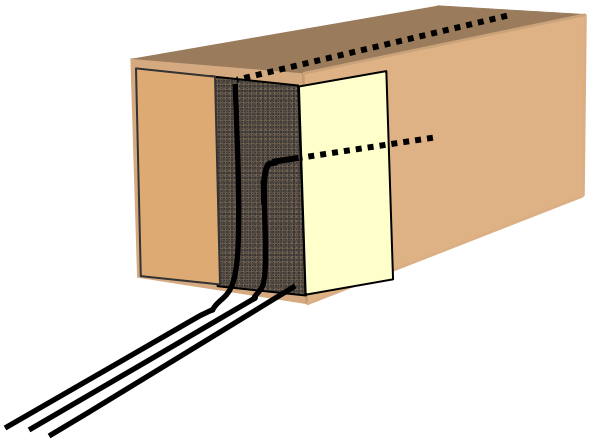
No of pieces …….

Shipping mark or brand ……..

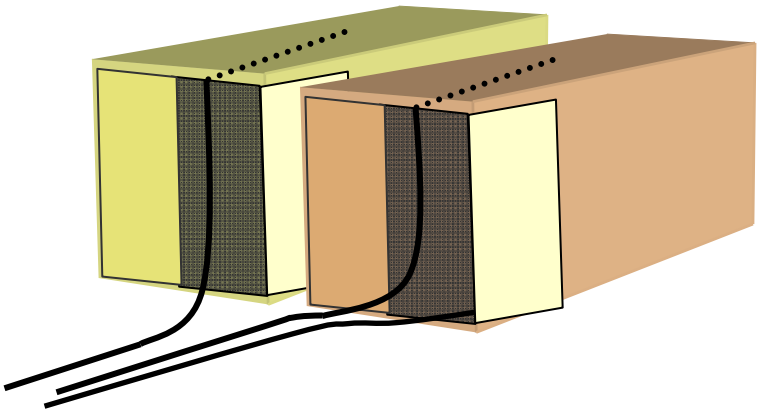
Treatment provider signature …….. Date ……../……./……..

Annex E
(normative)

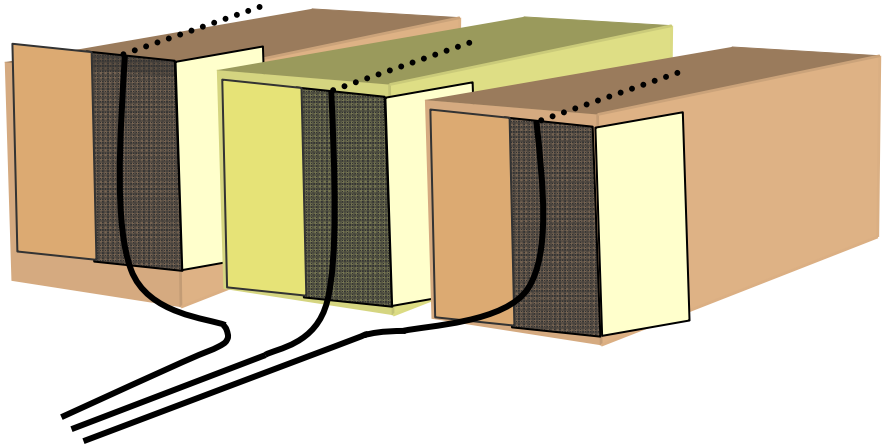
Monitor tube placement for container fumigation



a) One container in one enclosure (Three gas monitoring points)
One top back , one middle centre and one front base of the container



b) Two containers in one enclosure (Three gas monitoring points)
One top centre of the commodity in each container, one front base of either container



c) Three or more containers in one enclosure
One gas monitoring point at the top centre of the commodity in each container

Figure E.1. Monitor tube placement for container fumigation

Annex F
(normative)

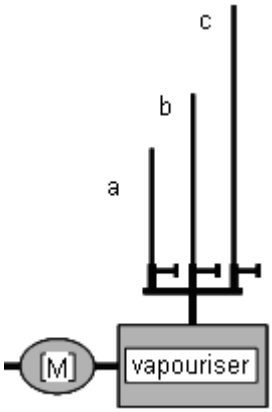
Arrangements of gas supply pipes for single and multiple manifold systems to ensure balanced distribution of fumigant gas into the fumigation enclosure

F.1 Multiple manifold systems

F.1.1 When gas is introduced into an enclosure through multiple supply pipes of differing length or diameter, the amount of gas flowing through each pipe will vary due to friction between the gas and sides of the pipe, as well as the flow dynamics of the gas.

F.1.2 For gassing pipes of unequal length or diameter (see Figure F.1 a), equal quantity of gas is applies through each gassing pipe in turn.

F.1.3 For gassing pipes of equal length or diameter (see Figure F.1 b), equal quantity of gas is applies through all gassing pipe at the same time.

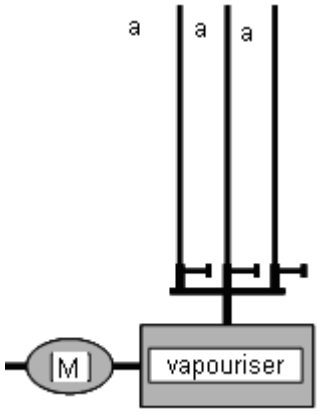


Key

M volumetric measuring device (dispenser) or scales

a/b/c gassing pipes

a) Gassing pipes of unequal length or diameter



Key

M volumetric measuring device (dispenser) or scales

a gassing pipes

b) Gassing pipes of equal length or diameter

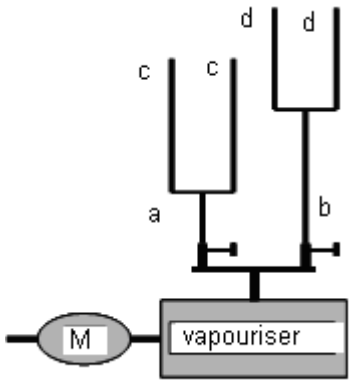
Figure F.1. Multiple manifold systems

F.2 Complex systems

F.2.1 These examples demonstrate possible methods of creating balanced systems for distribution of fumigant gas.

F.2.2 Multiple manifold systems are the most adaptable, allow for quick, safe and effective fumigation and are recommended.

F.2.3 For complex system (see Figure F.2), equal quantity of gas is applying through each tap (a and b) in turn.



Key

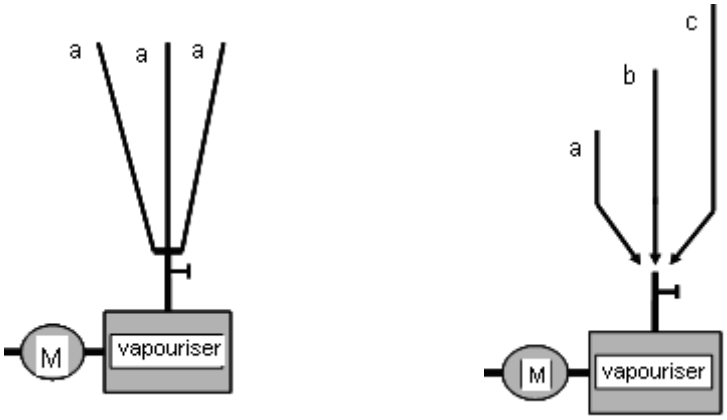
M volumetric measuring device (dispenser) or scales

a/b/c/d gassing pipes

Figure F.2. Complex systems

F.3 Single manifold systems

The overlying principle is that a balanced system will distribute the same volume of gas through each gassing pipe of the system at the same time. If it is not possible to achieve a balanced system then balanced application should be achieved by distributing measured amounts of gas through each gassing pipe of the system in turn. See Figure F.3 for single manifold systems.



Key

M volumetric measuring device (dispenser) or scales

a/b/c gassing pipes

Figure F.3. Single manifold systems

Annex G
(informative)

Vapourisers for methyl bromide

G.1 Vapourisers can be made in several ways. The three photographs (Figure G.1) below show a vapouriser that can be used by fumigators.

Figure G.1. Vapouriser

G.2 This vapouriser consists of three parts:

a) a gas (Liquefied Petroleum Gas (LPG)) burner that provides heat (Figure G.2);

b) a large water container; and

c) a cowling (or cover) placed around the gas burner.

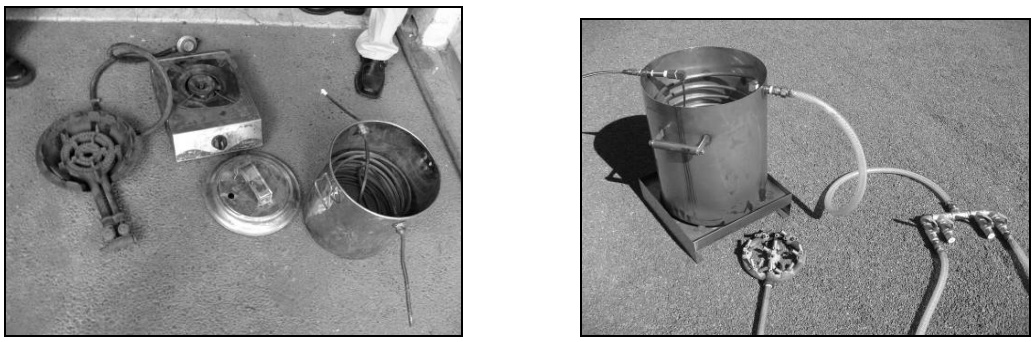


Figure G.2. The gas burner

G.2.1 A burner suitable for cooking large qualities of food is ideal. It should have two or three rings, so that it can very rapidly boil the water in the container and hold it above 6 °C while liquid methyl bromide passes through the heat exchanger. To control the amount of heat produced, each burner ring should have its own gas supply with a separate tap.

G.2.2 The water container

This should be made from stainless steel. Inside the container there is a double coil of copper pipe (the heat exchanger). As liquid Methyl bromide passes through this pipe, it takes heat from the water and is vapourise so the methyl bromide is delivered into the enclosure as a gas.

To make sure that any warning agent (chloropicrin) included in the methyl bromide is fully vapourised, the temperature of the water should not be allowed to fall below 65 °C.

Handles should be fitted to the top of the container to make it easy to carry. The handles should be large enough to allow a length of bamboo or other suitably sized piece of timber to pass through them. This will allow two people to safely carry the vapouriser when it is filled with water.

To prevent any liquid methyl bromide passing through the heat exchanger into the enclosure, fumigators should always make sure that the temperature of the water remains at, or above 65 °C by carefully regulating:

a) the amount of heat applied to the water; and

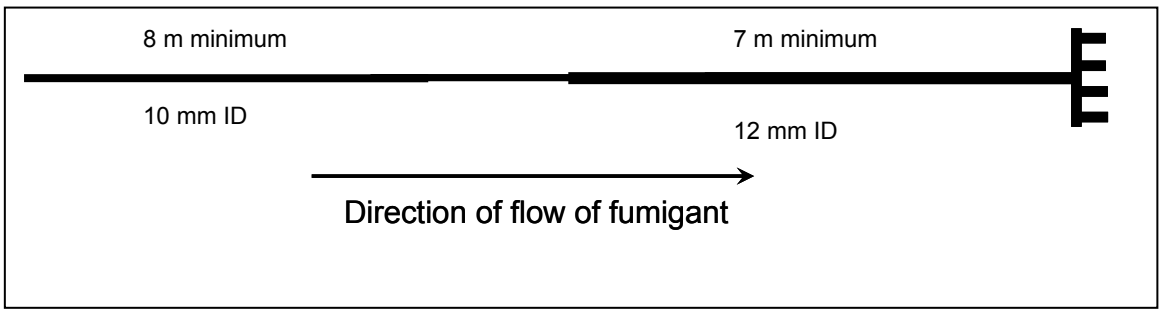
b) the speed at which liquid methyl bromide is allowed to flow into the vapouriser.

G.2.3 The cowling

A cowling is needed to direct the heat produced by the burner up and around the sides of the water container, and to protect the flames from sudden gusts of wind.

G.3 Technical drawings

To allow fumigators to construct a vapouriser, the drawings below (see Figure G.3) indicate the size of the parts of the vapouriser illustrated in the photographs above.



Key

ID internal diameter.

Figure G.3. Technical drawings on the size of the parts of the vapouriser

G.4 Material required to make this vapouriser:

a) Stainless steel sheer 1.6 mm thick, should be used for the water container and cowling because mild steel sheet rusts very rapidly.

b) 12 m of 12 mm outside diameter copper pipe, for the heat exchanger, the pipe should be twisted into a double coil for this purpose. The whole coil should provide a heat transfer surface of about 0.1 square metre for each kilogram of fumigant to be vapourised per minute.

c) A three ring gas burner.

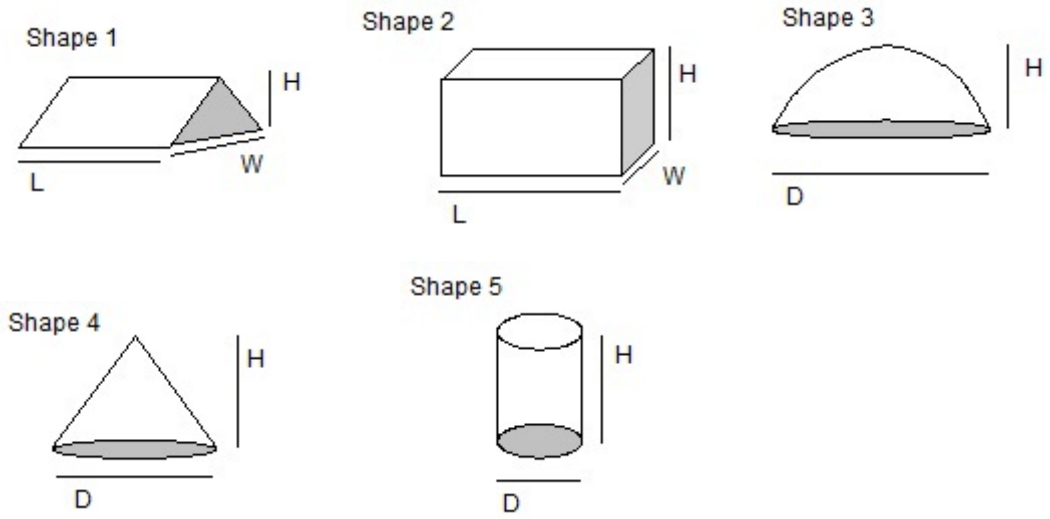
d) Brass and copper fittings, as required to attach the heat exchanger to the water container and so that connections can be made to the cylinder of liquid methyl bromide at one end, and to the pipe used to deliver gas into the enclosure.

e) A reliable dial thermometer, may be fitted to the water container to measure the temperature of the water.

Annex H
(informative)

Calculating the volume of differently shaped fumigation enclosures

The following guidelines may be used to assist in calculating the volume of differently shaped fumigation enclosures (Figure H.1):



Key

L length;

W width;

H height;

R radius (Diameter/2);

D diameter (Radius x 2); and

π (Pi) 3.142 (22/7).

Figure H.1. Differently shaped fumigation enclosures

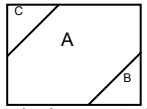
The internal volume of a fumigation enclosure can be calculated by adding up the volume of its parts.

Shape 1 (triangular prism): 1/2(L x W x H)
Shape 2 (rectangular prism): L x W x H
Shape 3 (dome): 2/3(π x R x R x R)
Shape 4 (cone): 1/3(π x R x R x H)
Shape 5 (cylinder): π(R x R) x H

Annex J
(normative)

Monitoring Ready Reckoner for methyl bromide

Table J.1. Monitoring Ready Reckoner for methyl bromide

Dosing phase	Initial dosage	24 g/m^3	32 g/m^3	40 g/m^3	48 g/m^3	56 g/m^3	64 g/m^3	72 g/m^3	80 g/m^3	128 g/m^3	Dosing is complete once all the required amount of gas has been applied to the enclosure.
Gas distribution phase start point	½ h to 1 h after gas Introduction (75 % or more of initial dose)	24.0 / 18	32.0 / 24	40.0 / 30	48.0 / 36	56.0 / 42	64.0 / 48	72.0 / 54	80.0 / 60	128 / 96	Start point is achieved when all monitor readings are at or above the standard and within 15 % of the lowest reading (Equilibrium). The duration of the fumigation is measured from when the start point is achieved.
	> 1 h after gas Introduction (70 % or more of initial dose)	24.0 / 16.8	32.0 / 22.4	40.0 / 28	48.0 / 33.6	55.0 / 39.2	64.0 / 44.8	72.0 / 50.4	80.0 / 56	128 / 89.6 / 89.6	
Fumigation phase methyl bromide concentration after start point	2 h after start point (60 % or more of initial dose)	19.4 / 14.4 / 9.4	24.2 / 19.2 / 14.2	29.0 / 24 / 19.0	33.8 / 28.8 / 23.8	38.6 / 33.6 / 28.6	46.4 / 38.4 / 30.4	51.2 / 43.2 / 35.2	48.0 / 40 / 32.0	72.0 / 64 / 55.0	The exposed period commences when the start point has been reached. For example, if a 24 h fumigation reaches start point 1 ½ h after dosing the fumigation is considered complete 25 ½ h after dosing and all concentrations are at or above the standard specified for 24 h.  A = standard concentration B = minimum concentration to allow top up C = maximum top up concentration *Methyl bromide concentrations less than 3 g/m^3 are below the threshold for effectiveness.
	4 h after start point (50 % or more of initial dose	17.0 / 12 / 7.0	21.0 / 16 / 11.0	25.0 / 20 / 15.0	29.0 / 24 / 19.0	33.0 / 28 / 23.0	40.0 / 32 / 24.0	44.0 / 36 / 28.0	36.0 / 28 / 20.0	52.8 / 44.8 / 36.8	
	12 h after start point (35 % or more of initial dose)	12.2 / 7.2 / 3.0	14.6 / 9.6 / 4.8	17.0 / 12 / 7.0	19.4 / 14.4 / 9.4	21.8 / 16.8 / 11.8	27.2 / 19.2 / 11.2	29.6 / 21.6 / 13.6	32.0 / 24 / 16.0	46.4 / 38.4 / 30.4	
	24 h after start point (30 % or more of initial dose)	12.2 / 7.2 / 3.0 *	14.6 / 9.6 / 4.6	17.0 / 12 / 7.0	19.4 / 14.4 / 9.4	21.8 / 16.8 / 11.8	27.2 / 19.2 / 11.2	29.6 / 21.6 / 13.6	32.0 / 24 / 16.0	46.4 / 38.4 / 30.4	
	48 h after start point (25 % or more of initial dose)	11.0 / 6 / 3.0*	13.0 / 8 / 3.0*	15.0 / 10 / 5.0	17.0 / 12 / 7.0	19.0 / 14 / 9.0	24.0 / 16 / 8.0	26.0 / 18 / 10.0	28.0 / 20 / 12.0	40.0 / 32 / 24.0	

NOTE. Methyl bromide concentration (g/m^3) required to meet this standard.

Annex K
(normative)

Examples of 'top-up' calculations

Figure K.1 graphically shows what should happen to methyl bromide levels during a well-sealed, sheeted fumigation, based on the values in Table 4 and an initial dosage of 48 g/m^3. Also shown are the boundaries around the standard concentration, below which the fumigation will not be acceptable. The middle line (standard concentration represents the theoretical progress of a fumigation treatment in a well-sealed sheeted fumigation enclosure.

The middle line is the standard concentration (value A in the Methyl Bromide Fumigation Ready Reckoner).

The lower boundary is the minimum concentration to allow top-up (value B in the Methyl Bromide Fumigation Ready Reckoner).

The upper boundary is the maximum top-up concentration (value C in the Methyl Bromide Fumigation Ready Reckoner).

If the methyl bromide concentration falls below the minimum concentration then the fumigation has failed and a top-up may not be carried out.

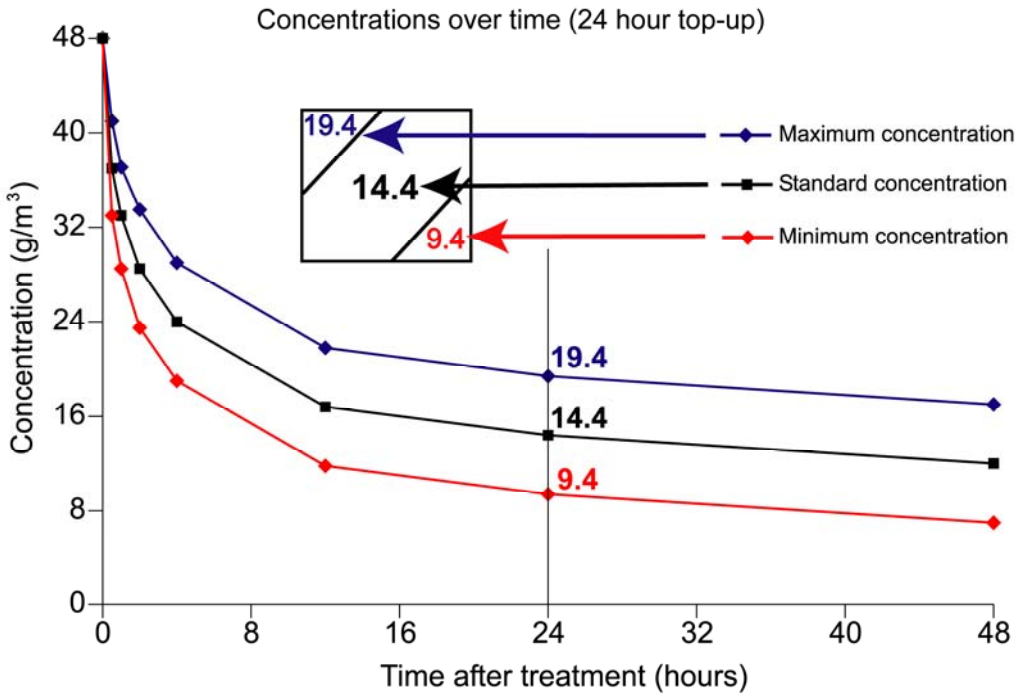
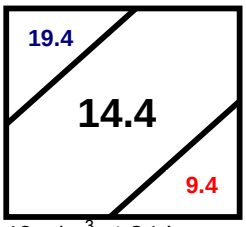


Figure K.1. Graphic to illustrate use of top-up procedure

There are two examples of top-up calculation as indicated below:

EXAMPLE 1 Top-up at the end of the fumigation period



48 g/m^3 at 24 h

Fumigation has been carried out, applying methyl bromide at 48 g/m^3. At 24 h the lowest fumigant concentration at the monitor points is 12 g/m^3.

12 g/m^3 is below the standard for 48 g/m^3 at 24 h (14.4 g/m^3, as shown, centre figure) but above the minimum concentration to allow top-up (9.4 g/m^3 as shown, bottom right figure).

The standard allows for the fumigant concentration to be topped-up to the maximum top-up concentration (19.4 g/m^3 as shown, top left figure).

To determine the amount of fumigant to be added to the enclosure, subtract the lowest concentration from the maximum top up value, as shown below:

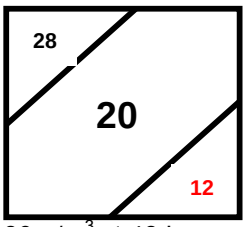
$$19.4 - 12 = 7.4 \text{ g/m}^3$$

This figure is then multiplied by the volume of the enclosure to determine the total dosage to be applied. The fumigant should be evenly distributed to the entire enclosure, using a vapouriser, with fans operating.

$$\text{The total dosage} = 7.4 \text{ g/m}^3 \times \text{volume of the enclosure}$$

The fumigation period shall be extended by 4 h, at which time all monitor points shall read at or above the standard (for the 24 h standard figure). Where any concentration has dropped below the standard, only one top-up procedure is permitted.

EXAMPLE 2 Continuous top-up during the fumigation period



80 g/m^3 at 48 h

Fumigation has been carried out, applying methyl bromide at 80 g/m^3. At 48 h the lowest fumigant concentration on the monitor tubes is 15 g/m^3.

It is suspected that fumigant levels may drop below standard by the end of the fumigation and a decision to top-up is made.

The standard allows for the fumigant concentration to be topped-up to the maximum top-up concentration (28 g/m^3 as shown, top left figure).

To determine the amount of fumigant to be added to the enclosure, subtract the lowest concentration from the maximum top up value, as shown below:

$$28 - 15 = 13 \text{ g/m}^3$$

This figure is then multiplied by the volume of the enclosure to determine the total dosage to be applied. The fumigant should be evenly distributed to the entire enclosure, using a vapouriser, with fans operating.

$$\text{The total dosage} = 13 \text{ g/m}^3 \text{ x volume of the enclosure}$$

No extension of the fumigation period is required, as long as the concentration has not fallen below the standard. Multiple top-up actions may take place where the concentration has not fallen below the standard.

Annex L
(normative)

Example of a record of fumigation

Job details			
Job identification	Customer name	Start date of fumigation	Location
Description of consignment			
Target of fumigation		Container numbers /consignment identification	

Fumigation details			
The consignment complies with the following requirements of the *Standards.* *Adequate free airspace, no impervious surfaces or wrapping, maximum timber thickness & spacing* Yes ☐ No ☐			
☐ Sheeted containers Size: Qty ☐ Pressure tested container Decay Time = seconds		☐ Sheeted stack ☐ Chamber	Enclosure dimensions L H W Volume = m^3
Specified dose rate g/m^3	Exposure period h	Forecast minimum temp °C	Dose rate used g/m^3
Calculated dose g	Chloropicrin ☐ N/A % g	Actual dose applied g	Time dosing finished

Concentration readings

Phase	Time of reading	Standard g/m^3	Monitor line readings by location					Equilibrium calculation	Top-up dose
			1:	2:	3:	4:	5:		
Start								%	
								%	
During									
End									

Comments

Ventilation			
Initial TLV ppm	Date and time taken	2nd TLV reading ppm	Date and time taken
Fumigator in charge		Quarantine officer (if supervised)	
Name	Signature	Name	Signature

Bibliography

[1] *AQIS Methyl Bromide Fumigation Standard*, Version 1.7, Department of Agriculture, Fisheries and Forestry, Australia.

Acknowledgements

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