

SOP reference: **Fumigation of shipments**

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Standard Operating Procedure (SOP)

<h1>GUIDELINES FOR THE CONTRACTED FUMIGATION OF TRANSPORT UNITS WITH THE GAS PHOSPHINE</h1>

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Background

Fumigation is used to disinfest food commodities of insects or rodents. The food must be held in a gas-tight enclosure with a poisonous gas (phosphine) to kill all pests. The gas phosphine is highly toxic to humans and fatal accidents occasionally occur. The fumigation is undertaken with a specific dose of phosphine for a specific period of time and once the fumigation is completed the enclosure is ventilated to disperse any remaining gas that would be a hazard to human health. If any pests survive then the fumigation is regarded as a failure.

In some parts of the world, the gas methyl bromide may also be in use for fumigation but this substance is an ozone depletor and its use is being phased out under the terms of the Montreal Protocol. WFP food consignments should not be treated with methyl bromide.

A WFP Standard Operating Procedure (SOP) for phosphine fumigation of bag stacks of food commodities in warehouses is described elsewhere ([Fumigation of warehouse SOP](#)). Not all food is fumigated in warehouses, some may be treated whilst in transport units such as ships/barges, freight containers or rail cars where the commodity may be in bulk or bags. In these cases, the units may either be stationery while they are fumigated and then subsequently ventilated to disperse the fumigant gas prior to transit or, alternatively, after the fumigation has been initiated the units continue in transit before they are ventilated.

There are three particular problems concerning fumigation of transport units

- 1) There is a disadvantage in moving units under fumigation since air movement across the unit may lead to a corresponding pressure drop which has a tendency to draw the fumigant gas out from the unit, so reducing the chances of fumigation success.
- 2) Relatively few transport units are designed to be fumigated. For a safe and effective fumigation the units must be made gas-tight. Transport units such as bulk carriers or certain freight containers may have built-in gas-tight seals so that fumigation can be relatively easy to undertake and is likely to be successful. By contrast, 'tween decker' cargo ships, general freight containers and rail cars with no built in seals can be difficult to seal and when they are fumigated they may present dangers to health and are often not successful.
- 3) Transport units often hold very large quantities of grain. Effective distribution of fumigant in very large bulks may require special procedures, such as an air recirculation system.

These guidelines for the fumigation of transport units are intended to inform WFP staff about

- the conditions required to achieve safe and effective fumigation where food commodities is being held in a variety of transport units, and
- the main technical and safety issues that should be specified when procuring the services of a contractor to undertake the fumigation of a transport unit.

Unlike the WFP SOP for bag stack fumigation, where each step of the treatment is clearly described, these guidelines present a mixture of general principles and specific requirements, since unlike bag stacks, transport units vary widely in the fumigation problems they present and in some instances, especially very large scale fumigations, there are no agreed procedures and reliance is placed on the experience of the fumigator.

There are no specific international guidelines on the fumigation of rail cars. For ships and freight containers there are several documents that specify procedures with respect to safety but do not specify details of the fumigation method to be used. These include the International Maritime Organisation (IMO) 'Recommendations on the Safe Use of Pesticides in Ships (2002 edition)', Maritime Safety Committee Circular 1264 (May 2008) on the safety of fumigation of grain in ships' holds and Maritime Safety Committee Circular 1265 on the safety of fumigation of freight containers. GAFTA has also issued it own 'Code of Practice for Fumigation and Pest Control' (Sept. 2008) based on these document.

General rules applicable to the fumigation of all transport units (rail cars, freight containers, ships/barges)

1. Only the gas phosphine should be used for fumigations to be undertaken on behalf of WFP.
2. No attempt should be made to apply phosphine fumigation unless the unit is gastight.
3. Avoid fumigating fully sealed/lined bags of food commodity, such as WSB, CSB, wheat flour etc. Special procedures are required (<http://foodqualityandsafety.wfp.org/fumigation>).
4. Phosphine gas could be provided directly from cylinders or a gas generator but is usually generated from solid formulations of either aluminium phosphide (e.g. Phostoxin) or magnesium phosphide (e.g. Magtoxin). Solid formulations release gas on exposure to the moisture in air. They may be supplied as pellets or tablets, which decompose leaving a powder residue uncontained, making disposal relatively difficult, or as sachets or blankets composed of larger quantities in permeable containers making disposal easy.
5. Magnesium phosphide generates gas more quickly than aluminium phosphide and is only appropriate for use in fumigations where commodity temperatures are 15°C to 20°C. For fumigations undertaken under warm tropical conditions, only aluminium phosphide should be used. Phosphine fumigation should not be used when the commodity temperatures are below 15°C.
6. No attempt should be made to fumigate the commodity using aluminium or magnesium phosphide if grains are below 9% moisture content (or below 3.5% moisture in the case of oil seeds) or if the relative humidity within the unit is less than 25%. This would result in incomplete gas release.
7. No attempt should be made to fumigate with solid phosphide preparations where there is a danger of direct contact between the solid and liquid water (e.g. condensation, water leakage). In these circumstances, a flame may be generated leading to fire.
8. Where phosphine gas is to be recirculated by fan within a transport unit, to enable an effective fumigation, then this must only be done using a low flow rate fan of the correct specifications and must only be done within a gas-tight unit. Fans must have a blade tip speed of less than 40m/sec and should generate a differential pressure of less

than 10 kPa. High pressure fans present a risk of phosphine combustion and hence fire.

9. The current recommended dosage rate for phosphine is 2g of gas/ton or 1.5g of gas/m³ (3g of aluminum phosphide = 1g of phosphine gas). However, recommendations do change and it is important to check them from time to time. In addition, for the fumigation of very large bulks over extended periods higher dosage rates may be required. Both under-dosing and over-dosing can be a cause of fumigation failure and promote the development of insect resistance to phosphine.
10. Phosphine dosage rates are applied according to the internal volume of the transport unit and apply equally to full, part-filled or empty structures.
11. For typical bag stack fumigations, the success of a treatment can be determined by the measuring phosphine gas concentrations under the gas-tight sheet on the fifth day of treatment, which should be 150 ppm. For most transport units this type of check would not be possible since the fumigator is usually not in place at the end of the fumigation as the unit is still in transit. Alternatively the fumigation is planned for a much more extended period and no critical concentration is known.
12. When using tablets or pellets of phosphide, it is important that they are not piled on top of each other but placed in a single layer.
13. The recommended phosphine exposure period should be considered to start at the time of the completion of fumigant application.
14. The duration of phosphine fumigation should not be less than five days, preferably 7 days, and especially long exposure periods may be required for very large bulks.
15. The Threshold Limit Value for occupational exposure to phosphine is 0.3 ppm. The working environment should be at or below this value before people are allowed to enter into the spaces where food commodities have been fumigated. The TLV should be confirmed using a phosphine detector that is sufficiently sensitive to measure low gas concentrations (e.g. Daeger gas detector tubes).
16. In-transit fumigations present a serious danger to those opening units on arrival since fumigant gas may remain. Any units that have been under fumigation in transit must 1) be labelled accordingly so that they can be readily identified, and 2) at the time of opening they must be checked by a certified fumigator using gas

monitoring equipment and may not be unloaded until officially declared safe and the fumigation warning labels removed.

17. For 'tween decker' ships, freight containers or rail cars that are not specifically designed to be sealed, every effort should be made to fumigate the commodity as a bag stack in a warehouse, either before loading or after discharge. If this is not possible then fumigation in transit should be avoided, rather the units should be stationary during fumigation.
18. Correct disposal of fumigant residues is important. Solid phosphide reacts with the moisture in air to generate phosphine gas and either aluminium or magnesium hydroxide. The hydroxides are a light grey dust. If the phosphide has not fully reacted then the dust is potentially dangerous. In very large bulks of grain the residues are allowed to become mixed into the bulk, would soon fully react and would not be noticed by the consumer. For smaller quantities of grain, the phosphide is placed on paper plates or craft paper or may instead be confined to an easily disposable sachet. The residues on trays or in sachets should be either buried away from human habitation or alternatively placed in a bucket, mixed with a large volume of water containing a little detergent. After vigorous stirring the water may be poured down the drain.

Rail cars

Rail cars can be difficult to fumigate as it is rare that they are manufactured with seals making them gas-tight. Instead, vents, slides and doors may need to be thoroughly sealed using polythene sheeting and strong plastic tape (not paper based). Where possible, rail cars should be held stationary in rail siding for the full period of the fumigation (not less than 5 days). Movement of the rail cars will accelerate gas loss and jeopardise a successful fumigation.

The correct dosage of phosphide should be introduced as sachets, tablets or pellets. Tablets or pellets should be placed on trays or craft paper for easy removal of residues. As soon as the fumigant has been introduced then the rail car must be sealed and a warning notice fixed securely to the car indicating the following:

- a fumigation is in progress,
- the date of start of fumigation,
- the date of completion, and
- the contact details of the fumigator in charge.

At the end of the fumigation period, in sidings or at the destination, the rail car should be ventilated by the Fumigator-in-charge and gas levels checked to ensure safe working. Once the rail car has been declared safe the fumigation warning notice should be removed.

Freight containers

Food commodities in freight containers may be fumigated provided that the containers can be made gas-tight. If containers have the following conditions then they will be difficult to seal:

- floors made of timber planking (rather than a large plywood panels) especially if the planking is in poor condition.
- large areas of ventilation running the length of the top and bottom of the sides
- seals around the edges of the ventilators in poor condition
- ventilators inside at the floor/wall junction that ventilate to the exterior from the underside. These need to be sealed prior to stuffing the container.
- door seals damaged or partly missing.

If the sealing problems above apply then the containers will have fumigated under gas-tight sheets in a manner similar to a bag-stack fumigation. The containers would be placed on good hard standing (a concrete or tarmac area without obvious cracks), covered by a gas-tight sheet that is held in place with sand snakes. If the fumigation is to be done on the quay side then a double layer of sand snakes is recommended to help counteract wind action. The fumigant would be placed in the container and then the doors shut for the duration of the treatment.

Containers that would be suitable for fumigation following sealing are either those specially designed for fumigation or with all the following:

- a good floor, preferably made of a single plywood panel,
- doors with tight sealing, undamaged rubber gaskets,
- minimal or no ventilators to be sealed
- no damage to the container structure

Most freight containers are fumigated and ventilated prior to being loaded on a ship. This process typically takes 7 to 10 days.

Freight container fumigation to be completed before loading

The ventilators should be sealed using polythene sheeting and plastic sticky-tape; the correct fumigant dosage should be placed in the container and then doors sealed. A warning notice should be fixed surely to the container indicating that:

- a fumigation is in progress,
- the date of start of fumigation,
- the date of completion, and
- the contact details of the Fumigator-in-charge

As soon as the fumigation period is complete, the freight containers should be ventilated by opening the doors and allowing the remaining gas to escape and all phosphide residues removed and disposed of safely. Ventilation can take several hours and can be a natural process, or can be accelerated by mechanical means such as blowers or extractors.

As soon as ventilation is complete, the Fumigator-in-charge should certify that the container is safe, and mark the warning signs to show that it has been ventilated and the date of ventilation. The container may then be moved onto the ship. On the ship the container will not be treated as a container under fumigation.

Freight container fumigation to be completed in transit

For sealable freight containers, where the fumigation is intended to continue in transit, the fumigation should be initiated on shore and the containers should not be loaded onto the ship until 24h after the start of the fumigation, by which time there will be a reasonably uniform gas concentration throughout the cargo.

The ship's master should be informed prior to loading of freight containers under fumigation.

Any ventilators should be sealed using polythene sheeting and plastic sticky-tape; the correct fumigant dosage should be placed in the container and then doors sealed. When under fumigation, freight containers must have the doors fully secured before loading onto a ship, plastic or lightweight metal seals are not sufficient for this purpose. The securing arrangement must be such as to allow only authorized entry to the freight container. If container doors are to be locked, the means of locking should be of such a construction that, in case of emergency, the doors could be opened without delay. A warning notice should be fixed securely to the container in a location where it will be easily seen by persons attempting to enter the interior of the unit. The notice should be not less than 300 mm wide and 250 mm high, with markings in black print on a white background with lettering not less than 25 mm high and it should indicate:

- a fumigation is in progress,
- the date of start of fumigation,
- the date of completion, and
- the contact details of the Fumigator in Charge

The transport document for a fumigated freight container shall show the type and amount of fumigant used, the date and time of start and the completion of fumigation. In addition, instructions for disposal for any

residual fumigant, including fumigation devices if used, shall be provided. The warning notice shall remain on the unit until the following provisions are met:

1. the fumigated unit has been ventilated to remove harmful concentrations of fumigant gas and the unit declared safe by the Fumigator-in-charge; and
2. the fumigated goods or materials have been unloaded.

Stowage on deck should be at least 6m away from vent intakes, crew quarters and regularly occupied spaces. Containers under fumigation should only be stowed under deck when unavoidable and then only in a cargo space equipped with mechanical ventilation sufficient to prevent the build-up of fumigant concentrations above the toxicity levels (threshold limits) set by national agencies. The ventilation rate of the mechanical ventilation system should be at least two air changes per hour, based on the empty cargo space.

Ships/barges

Fumigation in the holds of ships or barges may be undertaken while the vessels are held at anchor or while they are in transit. Fumigations at anchor are to be preferred since the fumigation can be kept under the control of the Fumigator-in-charge and the ship's crew can be kept on shore, this reduces potential health risks.

For cargoes of *bagged grain*, the usual practice is to place solid fumigant generating preparation (tablets, pellets, sachets, blankets) onto the surfaces layer of bags and then seal the holds.

For cargoes of bulk grain, the solid fumigant preparation may be placed on the bulk surface and some fumigators may place blankets in a trench about 0.3m below the grain surface. However, as a rule of thumb it is not recommended to have only a surface application if the depth of the bulk is greater than 12m. In any bulk it is considered better for tablets to be distributed at various depths within the bulk using probes or they could be placed at different depths as a hold is filled with grain. A more modern and more effective approach is to supply phosphine gas to the hold (from cylinders or a gas generator) and recirculate the gas with an appropriate fan. Where solid preparations are used and there is no recirculation then long fumigation durations may be needed to give a successful outcome. The fumigation period may need to exceed 15 days; however, there are no agreed procedures. When the fumigant is supplied as gas and recirculated then a typical 5-7 day fumigation should be sufficient.

Cargo fumigation in transit

Fumigation in transit may only be done with the consent of the ship's master and with the agreement of the port state administration. There may also be additional flag state requirements to consider. At least two crew members should be trained by the Fumigator-in-charge as representatives of the master, responsible for ensuring that safe conditions are maintained on board after the Fumigator-in-charge has left. They should be familiar with the hazardous properties of the fumigant including its detection. In addition they should know the symptoms of poisoning, relevant first aid, special medical treatment and emergency procedures.

Before fumigation

Empty cargo spaces should be inspected for leaks by the Fumigator-in-charge and a trained representative (or another competent person). Checks should be made to determine whether the holds can be made sufficiently gastight to prevent leakage into the accommodation, engine

room or other living or work areas. Special attention should be given to bilge, ballast and ventilation systems. On completion of the exercise the Fumigator-in-charge should provide the master with a signed statement declaring whether or not the cargo spaces are fit for fumigation, or can be made so.

If safe to proceed, the Fumigator-in-charge should give written notification to the master of the loaded cargo holds to be fumigated, and of all spaces which should not be entered during fumigation. The details should also include spaces adjacent to the cargo holds where leaking gas may result in phosphine accumulation. Warning notices should be posted outside all such locations before the fumigant is applied. Notices should also be placed on any entrances to holds and on hold covers.

After application of fumigant

Once the fumigant has been applied, the Fumigator-in-charge together with trained representatives of the master should identify and rectify any leakage from the cargo spaces. After a suitable period of time the accommodation, engine room and other working spaces should be checked for harmful concentrations of gas. The Fumigator-in-charge should also confirm that the vessel's gas detection and respiratory protection equipment are in good order, and that sufficient consumables to facilitate sampling throughout the voyage are carried. All warning notices should remain in place. Provided the master is satisfied that the cargo spaces are gastight and that all the required checks and safeguards have been fulfilled, the vessel may sail.

However, it may sometimes be necessary for the vessel to remain in port to allow the fumigant to reach a concentration high enough to identify any possible leakage. This situation is more likely if no recirculation system is fitted, it may take between four to seven days before gas can be detected. Alternatively, the Fumigator-in-charge should remain on board after sailing until the gas concentration has risen to a detectable level, or until the cargo spaces have been discharged, whichever is shorter. Once the Fumigator-in-charge has finished and on leaving the vessel, he should transfer the responsibility for maintaining safe conditions in all occupied spaces to the master and provide the master with written statements as follows:

- (a) The gas in the cargo space(s) has increased to a level whereby any leakage would be detectable.
- (b) The spaces adjacent to the treated cargo space(s) have been found to be gas free.

(c) A trained representative is fully conversant with the use of the gas detection equipment provided.

(d) The type of fumigant, associated hazards (e.g. fire risk) and the Threshold Limit Value (TLV).

(f) The time after which the fumigation will be complete.

(g) The procedure for the dispersal of any remaining fumigant at the end of the fumigation period.

(h) The procedure for the safe disposal of any fumigant residues at the end of the fumigation period.

After the fumigation process has started and throughout the voyage, all occupied areas and working spaces should be checked for traces of gas at least every eight hours, or more frequently if recommended by the Fumigator-in-charge. All readings should be entered in the deck logbook. Should the concentration of gas in any occupied space is found to exceed the TLV then steps must be taken to evacuate and ventilate the area concerned.

Prior to arrival

At least 24 hours notice should be given to the appropriate authorities at the vessel's destination, advising them that fumigation in transit is taking place and informing them of the type of fumigant, the date of fumigation, the cargo spaces treated, and whether ventilation to disperse the remaining fumigant has commenced.

On arrival

At the discharge port the local requirements for receiving fumigated cargo should be ascertained. Once established, the master should provide those responsible with detailed information regarding the fumigant together with the instructions for disposing of any fumigant residues. Before personnel are permitted to enter the cargo spaces, representatives from a fumigation company (or other authorised persons) wearing respiratory protection should monitor the gas concentration to ensure that no danger exists. It is particularly important to recognise that phosphide tablets may not always decompose completely during short passages. The monitored readings should be entered in the deck logbook.

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