

**DETIA  
DEGESCH**

**FUMIGATION  
SOLUTIONS**

AN INTERNATIONAL COMPANY FOR  
STORED PRODUCT PROTECTION

**PHOSPHINE  
FUMIGATION  
STANDARD**



# PHOSPHINE FUMIGATION STANDARD

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**Magtoxin<sup>®</sup>**

**MAGTOXIN TABLET**

FOR PROFESSIONAL USE ONLY

A gas-generating preparation containing Magnesium Phosphide 66% w/w for the control of insects which infest stored commodities and tobacco.

Gas-Generating Product (GEP)  
Active ingredients: Magnesium Phosphide 66%

Contains: 334 x 3 g spherical tablets  
Net weight: 1,000 g

IN CONTACT WITH WATER LIBERATES VERY TOXIC, HIGHLY FLAMMABLE GAS WHICH IS DANGEROUS TO THE HUMAN RESPIRATORY SYSTEM. OPEN CONTAINER IN A WELL VENTILATED SPACE. WHEN USING DO NOT EAT, DRINK OR SMOKE. AVOID ALL CONTACT BY MOUTH, SKIN AND CLOTHES. After contact with skin first remove contact with a dry cloth and then wash skin with plenty of water. EXTINGUISH ALL NAKED FLAMES INCLUDING PILOT LIGHT WHEN FORGOTTEN. WASH HANDS AND WASHED CLOTH BEFORE HANDS AND OTHER USE.

Environmental protection:  
Do not combine water with the product or its contents. Prevent access by livestock, cats and other domestic mammals, and birds to build up under fumigation and ventilation. Bags are protected against English Fleas, Spanish Natural Hair-taps or the Commodity Commission for Wares in Spain (MARC) and against insects.

DO NOT ALLOW TABLETS OR THEIR SPENT RESIDUES TO COME INTO CONTACT WITH FOOD OR FEED. KEEP ALL PEOPLE AND ANIMALS OUT of the fumigation area and adjacent areas into which gas might penetrate. Unprotected persons must be kept out of treated areas until the phosphine level has in the complete bag fallen below the TCV of 0.01 ppm.

Store in a cool, dry place.  
KEEP AWAY FROM FOOD, DRINK AND ANIMAL FEEDING STUFFS. KEEP OUT OF THE REACH OF CHILDREN. Empty containers completely using the method described under the heading 'Waste treatment'. Safe and sound disposal is essential with the instructions given under the heading.

# PHOSPHINE FUMIGATION STANDARD

## GLOSSARY OF TERMS

### TERM DEFINITION (IN THE CONTEXT OF THIS STANDARD)

Concentration	The amount of fumigant present in the fumigation enclosure, usually expressed as parts per million (ppm).
Dosage	The calculated amount of fumigant applied to a fumigation enclosure, usually expressed as grams per m <sup>3</sup> .
Exposure period	Period between introduction of the fumigant in the object to be fumigated and begin of ventilation, usually expressed as days or hours.
Fumigant	A toxic chemical substance, which at ambient temperature and pressure conditions exists in a gaseous state and which is applied to exterminate insects and other pests
Fumigation	The entire procedure related to the application of a fumigant for pest control purposes
Fumigation certificate	Documentation certifying that a fumigation treatment has been undertaken in compliance with legal requirements
Fumigation chamber	A permanent chamber used for fumigation purposes that meets the legal requirements for construction, use and maintenance
Fumigation enclosure	Any space or area designed to contain fumigant for the purpose of fumigation. Examples include gas-tight containers, gas-proof sheets sealed to an impermeable floor with sand snakes, and purpose built structures
Fumigation sheet	Plastic sheet material sufficiently gas-proof to create a temporary fumigation enclosure (also known as tarps or tarpaulins)
Gas-tightness	Capacity of holding a fumigant in sufficient quantity and over a sufficient period to facilitate successful fumigation
Hazardous 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 or risk area
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 (also known as monitoring line)
Occupational Exposure Limit (OEL)	Upper limit of the acceptable concentration of a hazardous substance in workplace air. In this case it refers to the phosphine concentration that a worker can be repeatedly exposed to in the workplace without harmful effects. It is based on an 8 hour day, 40 hour working week
Permeability	The rate at which a fumigant flows through a material (such as a fumigation sheet or a commodity)
Pest	Any organism that is detrimental to humans; in this case in particular to agricultural products or wood artefacts

<b>PH<sub>3</sub></b>	Structural formula for phosphine
<b>Phosphine generator</b>	Device for rapid production of phosphine gas from special metal phosphide formulations (e.g. granules) to be introduced into commodities or objects
<b>Quarantine pest</b>	A pest of potential economic and/or environmental importance to an area where it is not yet present, or is present but not widely distributed and is being officially controlled
<b>Resistance</b>	Decreased susceptibility of a pest population to a pesticide (e.g. phosphine) that was previously effective at controlling the pest. Pesticide resistance develops via natural selection
<b>Sand snake</b>	Sand filled tubes approximately 1 metre long used as weights to hold fumigation sheets in place during fumigation
<b>Self Contained Breathing Apparatus (SCBA)</b>	Respiratory protection gear that is not dependent on a remote air supply (e.g. a device using pressurized air)
<b>Sealing</b>	Rendering an object to be fumigated as gas-tight as possible
<b>Sheet fumigation</b>	A process of creating a gas-tight enclosure by covering the commodity to be fumigated under a gas proof sheet, which is sealed to an impermeable floor (generally using tapes, glue or sand snakes).
<b>Tolerance</b>	(1) Level of susceptibility of a pest population to a pesticide (e.g. phosphine). Tolerance of different species, populations or life stages (eggs, larvae, pupae, adults) may vary substantially. Sometimes the term „tolerance“ is also used for weak resistance. (2) Level of a hazardous substance that is acceptable by regulation, e.g. as a food contaminant
<b>Threshold limit value (TLV)</b>	Maximum concentration of a hazardous substance in any circumstance. One example for a TLV is the OEL.
<b>Warning sign</b>	Sign fixed to a fumigated object by legal requirement that indicates the hazard involved with fumigation
<b>Metal phosphide formulations</b>	Pressed compounds and bagged products, based on aluminium phosphide or magnesium phosphide
<b>Withdrawal period</b>	Period between gas-free release of the commodity after ventilation and earliest possible utilization



# Phostoxin®

## PHOSTOXIN TABLET

FOR PROFESSIONAL USE ONLY.  
A gas-generating preparation containing  
Aluminum Phosphide 56% w/w for the control  
of insects which infest stored commodities  
and tobacco.

Gas-Generating Product (GFP)  
Active Ingredients - Aluminum Phosphide 56%

Contains: 334 x 3 g spheric tablets  
Net weight: 1.000 g

IN CONTACT WITH WATER LIBERATES VERY TOXIC, HIGHLY FLAMMABLE GAS WHICH IS IRRITATING TO THE EYES AND RESPIRATORY SYSTEM. OPEN CONTAINER IN A WELL VENTILATED SPACE.  
WATER LIQUID DO NOT EAT, DRINK OR SMOKE. AVOID ALL CONTACT BY MOUTH, SKIN AND EYES.  
After contact with skin first remove product with a dry cloth and then wash skin with plenty of water.  
EXTINGUISH ALL BURNED FLAMES INCLUDING PILOT LIGHT WHEN FUMIGATING. WASH HANDS AND EXPOSED SKIN before meals and after use.  
Precautionary instructions:  
Do not combine with water with the product in its container. Proceeds released by insects, ticks and other organisms may irritate and leads to dermatitis under fumigation and ventilation. Bats are protected species (Small English Nettle, Scottish National Heritage or the Countryside Commission for Wales in appropriate cases) are present in buildings.  
Cautionary instruction:  
DO NOT BLOW TABLETS OR THEIR SPRAY RESIDUES TO COME INTO CONTACT WITH FOOD OR FEED.  
KEEP ALL PERSONS AND ANIMALS OUT of the fumigation area and adjacent areas into which gas might penetrate. Unprotected persons must be kept out of treated areas until the fumigation is complete.  
Use in the atmosphere that takes into this T.V. of 0.01 ppm.  
Other specific instructions:  
Storage and disposal:  
KEEP AWAY FROM FOOD, DRINK AND ANIMAL FEEDING STUFFS. KEEP OUT OF THE REACH OF CHILDREN. Empty container completely using the method described under the heading "Waste container disposal". We declare of safety in accordance with the instructions given under the heading

# PHOSPHINE FUMIGATION STANDARD

## PURPOSE & SCOPE

### PURPOSE

This standard sets out the minimum requirements for safe and effective fumigation using phosphine gas (PH<sub>3</sub>) in all formulations available on the market and registered. The standard includes all applications such as fumigating empty spaces (e.g. silo bins), transportation units (e.g. containers), and commodities in bulk or bag stacks.

If a specific country or customer requires a higher standard for any aspect related to the conduct of phosphine fumigation, then that higher standard must be followed.

### SCOPE

The scope of this standard is the application of any formulation of phosphine gas (e.g. pressed compounds, bagged products and gas released from high pressure cylinders or phosphine generators) for the purpose of fumigation of all kinds of objects and commodities in order to eradicate pest organisms (mainly insects) including quarantine treatment of transport containers. This standard includes all aspects of fumigation starting from pest prevention (e.g. sanitation) through preplanning of the treatment, transportation and storage of the fumigant, application, monitoring of gas concentrations, ventilation, gas-free release, disposal of degassed carrier material and record keeping.





# PHOSPHINE FUMIGATION STANDARD REQUIREMENTS

# PHOSPHINE FUMIGATION STANDARD

## 1 GENERAL REQUIREMENTS

### 1 GENERAL REQUIREMENTS – FRAMEWORK CONDITIONS FOR SUCCESSFUL FUMIGATION

#### 1.1 Fumigation is not a substitute for neglected prevention!

#### 1.2 Fumigation will only be successful under good conditions with regard to sanitation

The importance of any kind of prevention of pest attack cannot be over-emphasized. Buildings should be in a state that minimizes pest intrusion. Thorough and regular cleaning according to fixed plans is a precondition for pest prevention as cleaning minimizes the availability of food resources (spilled product!). Substantial accumulations of flour dust, etc. may serve as sources of insect outbreaks even after fumigation. In some cases phosphine gas penetrates such accumulations not fast enough to provide 100 % control of all insect stages. Keep records of observations that may have an influence on the success of fumigation (e.g. poor hygienic conditions in an object to be fumigated).

#### 1.3 No fumigation without justification (quarantine or pre-shipment requirements; pest presence detected during monitoring, etc.).

Fumigation without a sound justification is a waste of money and poses unnecessary risks, especially in terms of safety to humans and the environment.

#### 1.4 Always observe manufacturer's instructions (label)

Neglect of information provided by the manufacturer (dosage, time of exposure and other important instructions for use) may cause fumigation failures or create hazards that could be easily avoided.

#### 1.5 Observe all legal requirements

Phosphine fumigation is an operation involving a hazardous substance and is therefore strictly regulated in most countries. Important legal areas to be observed include:

- » Regulations on transportation of hazardous goods
- » Regulations on storage and application of hazardous substances
- » Regulations on occupational safety
- » Regulations on plant protection (including stored products)
- » Regulations on registration and use of pesticides
- » Regulations on consumers' safety (food and feed legislation)
- » Regulations on environmental protection (waste disposal, clean air, etc.)

National legislation in many countries involves personal and company licensing schemes for fumigant application, which are important preconditions for operating according to the law. Strictly adhere to the respective requirements.

Only well trained and certified fumigators should act as fumigator in charge and only well instructed personal should handle fumigants under the supervision of the fumigator in charge. This concerns workers of fumigation companies as well as workers from industry companies doing fumigation on their own responsibility. Where there is no certification requirement a company should take care that their fumigators are sufficiently trained according to international standards.

Apart from national legislation international law may apply, e.g. the IMO (International Maritime Organization) regulations and recommendations for safe use of pesticides on board of ships. Make sure that regulations of import countries receiving fumigated commodities are observed.

#### 1.6 If required adhere to standards and other particular requirements

Apart from legal stipulations and manufacturer's instructions there may be other rules or standards to be followed. If these are more restrictive than regulations in the legal framework they have to be observed to avoid complaints. One example are guidelines from the tobacco industry on phosphine fumigation, which set a tight frame of conditions for tobacco fumigation (e.g. minimum temperatures and exposure periods). Violating these guidelines may result in severe liability cases.

#### 1.7 Successful fumigation can only be performed under favorable climatic conditions.

Successful phosphine fumigation requires sufficiently high temperatures and, in the case of application of metal phosphide formulations, sufficiently high humidity of the air or commodity moisture. Generally temperature is the limiting factor. The most suitable range of temperature under which fumigation should preferably be performed is between 15 and 30 °C. Due to low biological activity of pest organisms, fumigation at temperatures below 10 °C, mainly in the commodity, is not recommended. Only special treatments, for example the fumigation of fresh fruits, may need different conditions and could be an exception.

As far as moisture is concerned regular commodity moisture values are sufficient for gas release from metal phosphide formulations. Fumigation of cereal grain is commonly carried out at moisture contents between 9 and 14 %. Apart from extremely arid climatic conditions, natural relative humidity of the air is generally sufficient.

Always keep records on the climatic conditions during fumigation, in particular the temperature inside the fumigated object/commodity.



### 1.8 Sites, objects and commodities must be suitable for fumigation.

Before starting fumigation, the object and/or commodity to be treated as well as its surroundings must be checked carefully taking into account its suitability for an efficient, successful and safe fumigation. It is important that all working steps can be performed without any hazard to humans (workers and bystanders) or the environment. Suitability for proper sealing is an important criterion for success and safety of the operation. If these conditions cannot be met, refrain from fumigation!

Take into consideration that phosphine corrodes precious metals such as gold, silver, copper and their alloys. Never fumigate rooms containing electronic equipment such as switchboards or computers, unless the equipment can be sealed effectively to prevent phosphine penetration.

Basically commodities with moisture content below 22 % can be safely fumigated with phosphine. However, there are also other commodities with a higher moisture content which can be fumigated. However, different parameters should be observed beforehand. The suitability of the commodity for contact with the fumigant should be known or checked and the right formulation of fumigant must be chosen in order to avoid quality losses.

# PHOSPHINE FUMIGATION STANDARD

## 2 REQUIREMENTS

### 2 REQUIREMENTS – WITH REGARD TO EFFECTIVENESS

#### 2.1 Proper sealing

The single most decisive factor for success of fumigation is sealing. Gas-tightness of an object to be fumigated depends on the type of material used in construction (metal or concrete walls of a silo bin or the plastic material used for fumigation sheet manufacturing) as well as on workmanship (e.g. sealing of joints). Objects that are not gas-tight by their nature (most silo bins, warehouses, containers, bag stacks under fumigation sheets) must be rendered gas-tight using state-of-the-art material and techniques (e.g. fumigation sheets and tight and flexible adhesive tape).

Fumigation sheets should be able to hold back phosphine molecules long enough to keep the required concentration until the end of the treatment (aeration). Gas tightness does not only depend on the thickness of the sheet but also on the material and its composition. Multi-layer sheets with a special barrier are the best choice. As it is not easy to determine whether a given sheet is sufficiently gastight it is recommended to purchase reliable purpose-built sheets. In order to fumigate larger objects several sheets have to be connected. Care should be taken to achieve gastight junctions (e.g. by welding or gluing with adhesive tape). To improve adhesive strength the sheet should be glued from both sides. Always check sheets for damage (fissures, holes) before use and re-use. Pre-fumigation tests to check gas tightness (e.g. use of smoke cartridges or approved pressure tests) are recommended to verify the quality of sealing before applying the fumigant.

#### 2.2 Dosage and concentration of the fumigant

The concentration of phosphine that is available for treatment after introduction of the fumigant to the object or commodity depends on two factors:

- 1) the applied dosage
- 2) the quality of sealing.

Dosage recommendations are provided by manufacturers and may be part of the registration according to national legislation.

With regard to dosage and exposure period it is important to note that the factors listed below play an important role in fumigation:

- » **Temperature and humidity**
  - They determine the rate of gas release from metal phosphide formulations – cool and dry conditions slow down gas release.
  - They influence pest metabolism – at low temperatures the metabolic rate is slowed down and the effect of phosphine is weakened.

- » **Insect species**
  - The sensitivity of different insect species to wards phosphine differs widely.
- » **Insect stage**
  - The insect stage determines sensitivity: eggs and pupae are generally more tolerant towards phosphine than larvae and adult insects.
- » **Tolerant strains**
  - Increased tolerance of insect strains towards phosphine can be a consequence of a too low dosage and/or too short exposure
- » **Fumigated products and package**
  - Density and composition of products to be fumigated determine penetration of the fumigant.
  - Some types of packaging (e.g. plastic foil) can slow down penetration considerably – attention: ventilation can also be delayed due to packaging!
- » **Leakage**
  - Gas loss that cannot be avoided by improved sealing should be compensated with higher dosage and/or longer exposure.

Ranges of dosage and exposure periods have been determined that take these factors into account. Well trained and experienced fumigators should be able to make the correct decision depending on the special situation on the spot.

Recommended dosages and exposure periods for metal phosphides are given in the table below. Trained fumigators should follow these recommendations unless experience shows that deviation is possible in case of optimum conditions.

#### RECOMMENDED DOSAGES AND EXPOSURE PERIODS FOR METAL PHOSPHIDES

	Dosage (g PH <sub>3</sub> /m <sup>3</sup> )	Exposure period (days)
Aluminium phosphide	5 - 10	5 - 14
Magnesium phosphide	5,5	2,5 - 5

Make sure that dosage calculation for a given object is done during the planning phase of the fumigation to organize timely supply of the fumigant and facilitate smooth and quick application.

### 2.3 Duration of the treatment

The exposure period starts with finishing the application procedure and ends with the start of the aeration process. Phosphine is a fumigant that requires sufficient time to act on the target pests in particular when temperatures are close to the lower limit of application. Raising the dosage cannot always compensate lack of time for exposure. This is why the recommendations made by the manufacturers and the stipulations included in legal texts and standards must be strictly followed.

Different temperatures require different exposure periods if all other parameters remain the same. The relationship between dosage and exposure period has been set forth in detail in section 2.2.

### 2.4 Management of the temperature

Low temperature necessitates longer exposure periods than higher ones and in extreme cases they provide conditions under which a treatment would fail (see section 1.7). If required, a fumigator can heat the object or commodity to be treated to obtain suitable temperatures.

### 2.5 Monitoring of the gas concentration

In order to make sure that the desired result will be achieved and for the purpose of safety for humans and the environment, regular monitoring of the gas concentration is required. For commodity fumigation the concentration must be read inside the bulk, bags or bales. This can be achieved by fixing monitoring lines leading outside the object to be fumigated during the preparatory work. Seal the outlet of the line during fumigation.

Gas measuring pumps with reactive tubes are appropriate for occasional gas recording. For regular measuring, electronic devices such as PIDs (photo ionization detectors) are preferable because they provide immediate results. Always have a substitute measuring device at hand in case of failure of equipment.

Only use approved equipment. Observe instructions for use, maintenance and calibration as prescribed by the manufacturer.

All gas records must be documented in a protocol that should be kept in the files of the company as stipulated in local regulations for at least two years.



# PHOSPHINE FUMIGATION STANDARD

## 3 REQUIREMENTS

### 3 REQUIREMENTS – WITH REGARD TO OCCUPATIONAL SAFETY

#### 3.1 Risk assessment

Formal risk assessment in written form is required for all fumigation tasks. It should involve all working steps (starting from the preparatory work until the gas-free release, disposal of degassed carrier material and cleaning up the site; see also section 3.2). Do not only consider the risk of exposure but all possible hazards such as mechanical damage or electric shocks, too. Most accidents that occur during fumigation are not caused by intoxication!

The risk assessment should specify risks related to every single working step or activity and describe protective measures on the level of organization (e.g. information), collective protection (e.g. good ventilation during distribution of solid phosphine preparations in a warehouse), and individual protection (e.g. respiratory protection – full face mask with filter B2 for inorganic gases with a grey color code).

A separate risk assessment is required for fumigators and for other people at a risk as protective measures may be different.

The risk assessment should indicate the responsible persons for protective measures and for the supervision of observing them.

#### 3.2 Working procedures

Fumigation can be broken down in a sequence of distinct working steps:

##### 1) PREPARATORY WORK

including inspection of the fumigation site and object, notification of authorities (if required), transportation and safe storage of the fumigant, sealing, etc.

##### 2) APPLICATION OF THE FUMIGANT

##### 3) MONITORING OF GAS CONCENTRATION (see also section 2.5)

##### 4) AERATION / GAS-FREE RELEASE

##### 5) DEACTIVATION AND DISPOSAL OF DEGASSED CARRIER MATERIAL

Important requirements concerning these five working steps shall be described in more detail in the following paragraphs:

##### 1) PREPARATORY WORK

- » Properly conducted inspection of the premises and/or goods to be fumigated is required in order to plan the job well in terms of material, time, man power and appropriate safety precautions.
- » Safe and effective work always requires well-organized procedures. Checklists, job cards, etc. are very helpful for this purpose. The fumigator in charge should always complete these documents during his work and sign at the end.

- » Inspect buildings carefully in terms of particular safety issues such as connections to adjacent buildings which might lead to gas loss and contamination of areas outside the fumigation zone (i.e. underground connections, conveyors etc.).
- » Notify authorities (supervising authority, fire brigade, medical emergency unit, etc. if required)
- » Inform customers on the details of the scheduled fumigation including hazards involved.
- » Organize fumigant provision just in time in order to avoid prolonged storage of this hazardous substance or make sure that safe storage is provided (locked warehouse, ventilated, water-proofed, sun-protected)
- » Make sure that fumigant is transported according to regulations for dangerous goods.
- » If short term storage is required on-site, take appropriate safety measures (locking, etc.).
- » If possible the fumigator in charge should obtain all keys of fumigated buildings in order to exclude unauthorized access during fumigation.
- » Seal as much as possible before starting application of the fumigant.

#### 2) APPLICATION OF THE FUMIGANT

- » Never work alone when handling the fumigant or when an exposure hazard cannot be excluded.
- » Observe general precautionary rules for handling hazardous substances. Do not eat, drink or smoke during work.
- » Hold packages such as flasks away from the body while opening to avoid hazards due to the development of gas in the flask.
- » Metal phosphide preparations should be evenly distributed in the object to be fumigated. If there is a risk of water intrusion (e.g. heavy rainfall, flooding), the fumigant should not be placed on the ground for degassing. Contact with water may create a fire hazard due to excessive phosphine gas production and auto-ignition.
- » If phosphine gas is introduced directly into commodities under sheets or objects using gas cylinders or generators, take care of good distribution using several shooting lines for larger spaces.
- » Do not keep leftovers of pellets or tablets for longer periods in flasks that have been opened before and never use anything other than the original container.
- » Packaging other than flasks should never be re-sealed; bagged products should always be used completely.
- » If gas monitoring results show that the concentration in the object under fumigation is lower than required look for leaks first and seal them if there are any.

- » If topping up with fumigant is necessary (and allowed according to country regulations!) do this work only wearing full face mask with filter B2 or, if required, SCBA and avoid exposure to the fumigant as much as possible (fast and well-coordinated work).
- » After work change clothes immediately because clothes could have dust residues or may be soaked with phosphine gas that could be inhaled.

### 3) MONITORING OF GAS CONCENTRATION (OEL)

One of the most important elements of occupational safety during fumigation is monitoring of phosphine concentration in enclosed areas (control of the Occupational Exposure Limit – OEL). As long as the OEL is not exceeded, work can be safely executed without respiratory protection. If higher concentrations are recorded workers should either leave the area or don a respiratory mask with the appropriate filter (see section 3.4).

Recording gas concentration for occupational safety purposes requires detectors of higher sensitivity than gas readings inside a fumigated object. A typical OEL-value, valid in many countries is 0.1 ppm for PH<sub>3</sub>. For gas detection pumps tubes with different sensitivity are easily available, while electronic devices such as electrochemical or photo ionization detectors (PIDs) in most cases require different sensors. Most often it is useful to carry two different detectors during fumigation for the different purposes.

See also section 2.5!

### 4) VENTILATION AND GAS-FREE RELEASE

During aeration the phosphine contained in the fumigated space is released into the air in a comparatively short period of time. Especially in the beginning of the operation concentrations of phosphine in the air close to the fumigated object can be particularly high. This is why special care must be taken and respiratory protection is mandatory (full face mask with filter B2 or SCBA). If ventilation is difficult due to the nature of the commodities or packaging (high residual phosphine concentrations after prolonged ventilation) active aeration by using fans is recommended. In case of special weather conditions like weather inversion postpone aeration.

Gas free-release requires the concentration of phosphine in the atmosphere of the fumigated object that is below the OEL. Reliable gas readings can be obtained after an object has been closed after ventilation for an additional hour and the gas reading is carried out after that.

A gas-free certificate must be issued according to local requirements and handed out to the owner of the fumigated object or commodity.

All warning signs must be removed before releasing the object or commodity.

Exception: Export containers should be provided with a warning sign that carries the statement: "Fumigated and ventilated" with indication of the respective dates.

### 5) INACTIVATION AND DISPOSAL OF DEGASSED CARRIER MATERIAL

Apart from ventilation the most hazardous working step in terms of possibility of inhaling phosphine is inactivation of degassed carrier material. Always wear respiratory protection equipment (full face mask with filter B2 or SCBA) when performing hazardous work.

Dry inactivation is preferred by many fumigators. It consists in leaving the carrier material in the open air until it does not release substantial amounts of phosphine any more. Care should be taken that the carrier material is protected from rain and that people who are not authorized cannot get access to it. The best way to achieve this is using metal baskets with a lid that can be locked up and stand in a protected hazard area marked with warning signs.

Another possibility for fast inactivation is placing the carrier material in bins containing water with some liquid soap to minimize surface tension. As gas release may be abrupt when inserting the material into the water respiratory protection must be worn during this work. Attention: Because of a particular fire hazard during this operation special care must be taken. Avoid throwing a lot of material into the water at the same time.

Perforate formulations other than pellets and tablets with a spike roller to facilitate contact of phosphide with water for optimum gas release.

Take care that products to be inactivated in water are submerged during the entire procedure. The use of metal baskets is recommended.

State-of-the-art inactivation involves special closed inactivation facilities that are equipped with a safe exhaust installation.

After proper inactivation the carrier material can be disposed of according to local regulations. Incineration and dumping in official sites are feasible options.

Never load degassed carrier material in unaerated vehicles for transportation to the disposal site. If local regulations permit, use open trailers and place fumigant in locked grid-boxes.

Dispose of empty packages together with inactivated carrier material. Render flasks unusable before dumping them. Keep records of disposed material.

Generally all steps of deactivation and disposal procedures of degassed carrier material must be done according to local regulations and could therefore be different in several countries and states.

# PHOSPHINE FUMIGATION STANDARD

## 3 REQUIREMENTS

### 3.3 Protective measures

Protective measures include good organization of the task, instruction and supervision of the workers and collective measures such as good aeration during distribution and application of fumigant and regular measuring of gas concentration in the airspace of the working place in order to control the OEL for phosphine.

Apart from the gas measuring equipment the most important protective item during fumigation is the full face respiratory mask with the appropriate filter. Half masks are not suitable for fumigation! The appropriate filter for phosphine is the B2 filter for inorganic gases with a grey color code. In dusty workplaces use a combination filter with particle filter of the class B2P2. It is recommended that filters should be replaced after every single fumigation or at the latest when saturation is reached. Always observe manufacturers' instructions and legal prescriptions for use. If circumstances require it the use of SCBA should be taken into consideration.

Other protective equipment may be required according to the special working environment or task performed including safety shoes and helmets, working gloves (especially for handling solid phosphides) and goggles (in dusty environments or when handling phosphide pellets or tablets).

### 3.4 First aid

As phosphine fumigation is a potentially hazardous operation, first aid precautions must be taken by any fumigating company. Trained fumigators should also have first aid training and first aid kits should be brought to every fumigation site. The first aid kit should include an inhaler with a steroid spray. Read the instructions carefully before starting work. Identify and mark emergency routes and exits and keep them free at any time.

Inform nearby medical doctors or hospitals on treatment in case of phosphine intoxication and keep information material such as material safety data sheet at hand during work. Regular training on first aid for the fumigation staff is recommended.



# PHOSPHINE FUMIGATION STANDARD

## 4 REQUIREMENTS

### 4 REQUIREMENTS – WITH REGARD TO GENERAL HEALTH PROTECTION AND PROTECTION OF THE ENVIRONMENT

#### 4.1 Surveillance of the fumigated object

During all steps of fumigation the fumigator in charge must make sure that nobody is harmed by the treatment. This objective can be achieved by means of creating a hazard area (i.e. use red/white or yellow/black chains or tapes) and making sure that nobody who is not involved in the fumigation enters the space. Warning signs must be fixed to the object under fumigation. They should carry a pictogram that indicates the intoxication hazard (skull with crossed bones) and the necessary information on the hazard involved and the coordinates of the fumigation company. A 24 hour emergency telephone number must be indicated where the fumigator in charge can be contacted in case of need.

In addition, regular gas monitoring around the fumigated object is required to control the atmosphere. Keep records of the results of the measurements gas-readings.

If a fumigated object is particularly hazardous due to its size, location or other circumstances security guards should be employed permanently.

#### 4.2 Ventilation and gas-free release

It has been pointed out in section 3.2 (4) already that during ventilation big amounts of phosphine are released into the air leading to high concentrations of the fumigant close to the fumigated object, in particularly during the first minutes. Make sure that nobody who is not involved in ventilation work is present in the hazardous area. Take possible drifting away of phosphine into consideration during windy conditions. Consult the local weather forecast.

#### 4.3 Inactivation of degassed carrier material and waste disposal

"Degassed" carrier material is never fully gas-free after fumigation. This is why an inactivation is required before disposal. As described in section 3.2 (5) there are basically two methods to achieve this:

- » Dry inactivation
- » Inactivation in water

During dry inactivation care should be taken that the carrier material is protected from rain. The best way to achieve this is using metal baskets with a lid that can be locked up and stand in a protected hazard area marked with warning signs.

Take care that people who are not authorized cannot get access to any degassing site.

As mentioned in section 3.2 (5) local regulations must be followed.

# PHOSPHINE FUMIGATION STANDARD

## 5 RESISTANCE MANAGEMENT

### 5 RESISTANCE MANAGEMENT

High tolerance of pest insects to phosphine has become a major concern during the last decades. Development of this tolerance in the past has been mainly caused by lack of respect of essential fumigation parameters such as proper sealing in the first place. Other reasons include improper dosage rates and duration of fumigation along with a lack of efficacy monitoring.

#### 5.1 Determining parameters to prevent risk of resistance

In order to obtain a good result during fumigation (i.e. 100 % pest control) the requirements set out in chapters 1 and 2 of this standard must be met:

- » Sufficiently high temperature
- » Proper sealing
- » Correct dosage and sufficient concentration of the fumigant
- » Sufficiently long exposure period
- » Active measurement of the concentration achieved during the fumigation

Even small deviations may result in survivors and particular in the naturally less susceptible egg or pupae stages. Such survivors may later be the source for tolerant populations after several generations of selection under similar conditions.

Good sealing is the key to successful fumigation!

#### 5.2 Testing of increased tolerance

If a fumigation fails (surviving insects!) check first whether all parameters listed in the previous section have been met during the treatment. If you are sure that there was no other factor involved that could have caused the failure make a field test. Tolerance Test Kits are available from fumigant suppliers. If the field test is positive, collect a sample of live adult insects and forward them to a laboratory that can confirm high tolerance.

If there is any reason to believe that pest insects to be controlled may be tolerant to phosphine, perform a field tolerance test first before trying to fumigate.

#### 5.3 Controlling tolerant insect pest populations

If circumstances and legal prescriptions allow, try to control tolerant pests with another method or fumigant other than phosphine. This is the best option in resistance management. If there is no other possibility try to fumigate with a higher concentration provided this solution does not violate the stipulations of phosphine registration in the country. Consult experts from fumigant manufacturers, plant protection agencies or research institutions concerning the right steps to take.

#### 5.4 Principles of resistance management

Resistance management should always consider that operational factors are generally more easily controlled than biological ones. Operational resistance management options may include:

- » Observation of post-harvest IPM principles from the very beginning (especially prevention and monitoring)
- » Use of alternative methods of post-harvest protection wherever feasible (contact insecticides, physical methods such as heat treatment, cooling of grain, modified atmospheres, biocontrol, etc.)
- » rotation (use of an alternative fumigant to control PH<sub>3</sub>-tolerant strains) – if availability on the market, registration and other factors allow
- » use of phosphine only in well-sealed enclosures (use of state-of-the-art techniques of application and sealing)
- » use of gas-recirculation systems for bigger silos and ships

Document and report to authorities all cases of insect tolerance observed.

# PHOSPHINE FUMIGATION STANDARD

## 6 REQUIREMENTS

### 6 REQUIREMENTS – WITH REGARD TO DOCUMENTATION AND CERTIFICATION

Fumigation is a potentially hazardous operation that requires substantial paperwork. Documents involved include the ones listed below (requirements may differ from country to country):

- » notification of fumigation to supervising authorities
- » documentation of risk assessment
- » documentation of execution (job cards, checklists, etc.)
- » gas-free certificates
- » fumigation certificates

It is important to keep all these documents in the company files as long as local regulations require (if no regulation in this regards exists a minimum period of two years is recommended).







# PHOSPHINE FUMIGATION STANDARD

**ANNEX**

# PHOSPHINE FUMIGATION STANDARD

## ANNEX 1

### ANNEX 1

#### EXAMPLE OF SAFE FUMIGATION PRACTICE CHECKLIST

##### Before fumigation

- Object to be fumigated inspected
- Authorities notified (if required)
- Customer, workers, neighbors and other people possibly at risk are informed on fumigation, hazards and precautionary measures
- Risk assessment including protective measures completed with special consideration of the issues listed hereafter:
  - » Inhalation hazards
  - » Hazards caused by metal phosphide dust
  - » Risk of traffic accidents, in particular on container terminals
  - » Risk of injury by tools and machines, falling over and falling down, etc.
  - » Reduced field of vision when wearing a full face respiratory mask
  - » Risk of electrical shocks
  - » Physical effects such as heat or noise
  - » Fire and explosion hazards caused by the fumigant or other sources
  - » Hazards cause by heavy work
- Fumigation plan completed to include timing and distribution of work and dosage calculation
- Fumigation team nominated and instructed; fumigator in charge nominated
- Fumigant ordered
- Material safety data sheet of the fumigant and other relevant information (including first aid instructions and additional information for medical treatment in case of intoxication) prepared along with the fumigant label which is required in the U.S.
- All necessary material prepared (use special checklist)
- Material and equipment checked for proper state and function (in particular gas measuring devices and respiratory protective gear)
- Weather forecast consulted if required
- Sealing prepared and checked (smoke cartridge or pressure test if applicable)
- Warning signs prepared and hazardous area established and clearly marked

##### During fumigation

###### Application:

- People not involved in fumigation work have left the site
- All material at the site (in particular fumigant, sealing material, gas measuring devices, respiratory protection gear, first aid kit)

- All necessary documents at the site (material safety data sheet, first aid instructions, etc.)
- Warning signs filled in and fixed
- All workers properly instructed
- If required, watchman placed at the only entry to the object to be fumigated (other entries have been locked before)
- Fumigant applied in correct dosage according to plan
- Fumigated object properly sealed
- Sealing tested with a gas monitor
- Object locked up safely

##### Exposure period:

- Regular gas monitoring is performed according to a pre-established schedule (see gas monitoring protocol)
- In case of topping up fumigant: Respiratory protection ready and used by all persons involved

##### Termination of treatment:

- Parameters for successful fumigation achieved: temperature, concentration, exposure period
- Respiratory protection ready and used for opening of sealing
- Required aeration period observed
- Final gas reading performed
- Object opened for fumigation workers (after phosphine concentration is below OEL) and carrier material taken out

##### After fumigation

- Object/commodity released
- Gas-free certificate issued and handed over to customer
- Inactivation of degassed carrier material completed in a safe way and place
- Disposal of inactivated carrier material completed and documented
- Material such as fumigation sheets, tapes, etc. removed and object left in proper condition
- Documentation completed (fumigation certificate, fumigation report, etc.)

##### Confirmed:

.....  
Place and date

.....  
Signature of fumigator in charge

# PHOSPHINE FUMIGATION STANDARD

## ANNEX 2

### ANNEX 2 SPECIAL PROCEDURES FOR CONTAINER FUMIGATION

- » Fumigation of containers is often carried out on terminals where particular hazards may exist and special safety regulations apply – study safety instructions of the terminal carefully and always follow them.
- » Be aware of hazards from terminal traffic – reach stacker and straddle carrier drivers have a limited field of vision in their vehicles! Move with utmost care.
- » When working on terminals always wear a yellow or orange warning vest, safety helmet and safety shoes. Vehicles should be equipped with rotating beacons.
- » Containers are not gas-tight without adequate sealing – if possible check container thoroughly before loading (enter during day and close door so that you can detect any leakages or use smoke cartridges) – seal any leakages that you detect. Seal ventilation openings preferably from inside. Floor and door joints are the most critical places – place container on even and gas-tight ground for fumigation and seal doors properly with high quality tape.
- » Avoid fumigation of containers standing on uneven ground (particular hazard of gas leaks due to twisting and doors that do not close tightly)
- » Avoid fumigation of containers that are placed on top of each other (additional occupational safety hazard and risk of gas loss due to weather especially increased exposure to wind)

- » Fix warning signs according to IMO stipulations:



- » Secure containers under fumigation against uncontrolled picking up by means of a shackle or chain with padlock fixed in one of the upper corner castings.
- » Check gas concentration inside the container/commodity (use gas reading lines put in place before fumigation) and outside (all around) daily and keep records. Fix a gas measuring protocol to the container door.

# PHOSPHINE FUMIGATION STANDARD

## ANNEX 3 & 4

### ANNEX 3

#### SPECIAL PROCEDURES FOR BAG STACK FUMIGATION

- » Close the warehouse where the fumigation takes place for all persons not involved in the operation before starting application. If this is not possible perform regular checks of the OEL.
- » Protect workers against falling from bag stacks – use climbing safety equipment (belts, ropes).
- » Distribute fumigant evenly and avoid having large amounts of metal phosphides in close proximity (auto-ignition hazard!). Do not place metal phosphides directly on the floor if there is any hazard of the intrusion of water.
- » When sealing take care that the floor is even and sufficiently gas-tight – if these conditions are absent, restack on a tight tarpaulin.
- » The floor should be thoroughly cleaned before applying any glue for sealing in order to increase adhesion.
- » If sand snakes are used for sealing put them on the floor with about one third overlap.
- » Give special attention to the sealing of the corners. As many folds appear at these places the risk of leakages is particularly high there. Learn from experienced fumigators.
- » Check gas concentration regularly according to schedule established before the fumigation.

### ANNEX 4

#### SPECIAL PROCEDURES FOR FLAT STORAGE FUMIGATION

- » Electrical power should be cut off.
- » Close the warehouse where the fumigation takes place for all persons not involved in the operation before starting application. If this is not possible perform regular checks of the OEL.
- » Protect workers against falling from top of grain surface – use climbing safety equipment (belts, ropes).
- » Provide enough working force to finish the job as fast as possible. Assign tasks to everybody beforehand, e.g. watching at the door and keeping a list of persons entering and leaving – opening of fumigant containers – applying the fumigant – covering the grain with fumigation sheet and sealing – collecting and removing packages and other items that are not needed any more.
- » Start work from warehouse side away from the door or gate and proceed towards it.
- » Distribute fumigant evenly and deep enough using techniques recommended by manufacturers (e.g. special probes for tablets, pellets or belts).
- » If the fumigant is a blanket formulation (inter-connected bag formulation of a certain length) it is best to do a subsurface application. Never apply the blankets to the top of the grain. The most convenient way is digging ditches about 20 cm deep into the grain surface before rolling out the blankets. For the removal of the blankets leave the attached banner outside the grain mass.
- » While working as a fumigation crew in big warehouses the use of walkie-talkies for communication is recommended.

# PHOSPHINE FUMIGATION STANDARD

## ANNEX 5 & 6

### ANNEX 5

#### SPECIAL PROCEDURES FOR SILO FUMIGATION

- » Electrical power should be cut off.
- » Close the silo complex where the fumigation takes place for all persons not involved in the operation before starting application. If this is not possible perform regular checks of the OEL especially in the basement and head areas of the building.
- » Check whether silo bins to be fumigated are connected with others and if so seal all connections. Disconnect the dust-exhausting system.
- » Seal all openings on silo top (manhole, grain inlet) and outlet on the bottom well.
- » While applying fumigant make sure that the working area is well ventilated.
- » Use automatic dispensers for pellets and tablets to minimize contact with fumigant.
- » In case of application of metal phosphide fumigant by hand always use gloves.
- » In bigger silos application of phosphine with a gas recirculation system is strongly recommended in order to achieve fast and uniform fumigant distribution.
- » Dust residues from grain treated with tablets or pellets should be cleaned using aspirators.
- » While working as a fumigation crew in a big silo-complex the use of walkie-talkies for communication is recommended.
- » Never use elevators while fumigation is going on. In case of power failure persons might get stuck in a hazardous atmosphere.

### ANNEX 6

#### SPECIAL PROCEDURES FOR SHIP FUMIGATION

- » Follow the International Maritime Organization (IMO) recommendations on the safe use of pesticides on board of ships.
- » A sea going vessel will be out of the fumigator's control once it leaves the port where fumigation has been performed. Take special care beforehand that the crew is not exposed to any hazard that can be prevented before the ship starts its journey.
- » Check carefully gas tightness of the ship holds prior to fumigation, e.g. with smoke cartridges. Do the necessary checks and tests together with the master of the vessel.
- » Make sure that gas detection and respiratory protection equipment is left on board of the ship and that crew members are instructed on their use. Hand over written instructions to the master of the vessel.
- » Instruct all crew members on the fumigation, possible hazards, first aid and other emergency measures. As crews may be composed from different nationalities make sure that everybody understands the instructions.
- » If possible use a gas recirculation system when fumigating ship holds.
- » If the fumigant is a blanket formulation (inter-connected bag formulation of a certain length) it is best to do a subsurface application. Never apply the blankets to the top of the grain. The most convenient way is digging ditches about 20 cm deep into the grain surface before rolling out the blankets. For the removal of the blankets leave the attached banner outside the grain mass.
- » Place warning signs on all entries to fumigated holds.
- » Establish a routine of periodic OEL measurements in all enclosed spaces where crew members stay (living quarters, mess, bridge, engine room, etc.)
- » While working as a fumigation crew on board of vessels the use of walkie-talkies for communication is recommended.

# PHOSPHINE FUMIGATION STANDARD

## ANNEX 7

### ANNEX 7

#### SPECIAL REQUIREMENTS FOR FUMIGATION CHAMBERS

Purpose-built fumigation chambers are particularly well suited for safe and efficient fumigation of commodities. To satisfy these requirements, fumigation chambers must be constructed and operated according to the specifications listed below:

- » Solid construction from gas-tight material or provided with a gas-tight coating
- » Permanent gas-tight sealing all around including the door joints once the door is closed
- » Permanent installation of all necessary lines such as monitoring tubes, supply pipes or electrical cables. Installation carried out in a way to prevent any gas leakage
- » Built in circulation system to adequately distribute the fumigant throughout the chamber.
- » Inbuilt extraction system that actively removes the fumigant from the enclosure and vents it to the open air above the roofline or directs it for recapture
- » If required ventilation system working according to local clean air standards
- » If required equipped with a filter system for gas recapture
- » If required certified and supervised by technical authority
- » Regularly checked and maintained according to local requirements
- » All treatments documented in detail



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**DETIA DEGESCH GMBH**

Dr.-Werner-Freyberg-Str. 11  
D-69514 Laudenbach  
Tel: +49 (0)6201 - 708-0  
Fax: +49 (0)6201 - 708-402

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[export@detia-degesch.de](mailto:export@detia-degesch.de)  
[www.detia-degesch.de](http://www.detia-degesch.de)

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