



### FUMIGATION OF FARM STORED GRAIN AND STRUCTURES

Direct feeding damage by insects reduces grain Quality (physical appearance), Quantity (weight), nutritional value and germination. Insect infestation also causes contamination (diseases), odors, molds, and heat damage that reduces the market value of the grain and makes it unfit for processing into food for humans or livestock.

Phosphine is widely used for grain protection because it is cheap, simple to apply and has little effect on grain quality. Phosphine gas has no residue on products, eliminates all stages of insect pests, no resistance and is safe to workers and environment.

In view of the phase out of methyl bromide, the role of phosphine in grain protection has increased in recent times.

In order to kill grain pests at all stages of their life cycle (egg, larva, pupa, adult), phosphine gas needs to reach and be maintained at a concentration possible only in a gas-tight storage.

The total time required for effective fumigation ranges from 5–10 days, accounting for the minimum exposure, ventilation and withholding period.

To control pests at all life stages and prevent insect resistance, phosphine gas concentration needs to reach 300 parts per million (ppm) for five days (when grain is above 25°C) or 200ppm for seven days (between 15–25°C).

*Insect activity is slower in cooler grain temperatures so require longer exposure to the gas to receive a lethal dose.*

### INSECT PEST CLASSIFICATION

ORDER	EXAMPLES
Coleoptera	Beetles, weevils
Diptera	Flies, mosquitoes
Hemiptera	True bugs, assassin bugs, stink bugs, bed bugs, lygus bugs
Homoptera	Aphids, leafhoppers
Hymenoptera	Hymenoptera – Wasps, bees, ants, sawflies
Lepidoptera	Butterflies and moths
Orthoptera	Grasshoppers
Siphonaptera	Fleas
Thysanoptera	Thrips



### GENERAL TYPES OF INSECTS MOUTHPARTS

Chewing	Cockroaches, ants, beetles, caterpillars, and grasshoppers
Piercing/sucking	stable flies, sucking lice, bed bugs, mosquitoes, true bugs and aphids
Sponging	flesh flies, blow flies, and house flies
Siphoning	butterflies and moths

### COMMONLY ENCOUNTERED STORED GRAIN INSECTS

Feeding habits of storage insect pests are used to separate them into two classes: Primary pests and secondary invaders.

**Primary pests** are those that are capable of penetrating and infesting intact kernels of grain, and have immature stages that can readily develop within a kernel of grain.

**Secondary invaders** cannot infest sound grain but feed on broken kernels, debris, higher moisture weed seeds, and grain damaged by primary insect pests.

PESTS	COMMON NAME	SCIENTIFIC NAME
Primary pests	Lesser Grain Borer	Rhyzopertha dominica
Secondary invaders	Rusty Grain Beetle	Cryptolestes ferrugineus
	Granary weevil	Sitophilus granarius
	Red Flour Beetle	Tribolium castaneum
	Sawtoothed Grain Beetle	Oryzaephilus surinamensis
Other secondary pests	Hairy Fungus Beetle	Ahasverus advena
	Foreign Grain Beetle	Ahasverus advena
	Booklice	Psocoptera
	Mites	Acarina
	Meal Moth	Plodia interpunctella

### CONDITIONS THAT ENCOURAGE STORED GRAIN INSECTS

Temperature, moisture, and grain dockage or dust interacts to provide conditions necessary for the reproduction and survival of stored grain insects.

### SOURCES OF INFESTATION

Some of the stored grain insects can fly and begin their infestation in maturing grain in the field.



### MONITORING INSECTS

Stored grain insects are widespread, numerous, very small and they can show up even in the cleanest, best managed environment. Regular checkup is important to be sure of detecting pests before they cause damage. A grain sieve, probe or scoop can be used to identify and examine insects in the grains.

### CRITICAL IPM ISSUES

The integrated pest management (IPM) approach that protects stored grain includes:

- ❖ Sanitation
- ❖ Frequent monitoring
- ❖ Aeration
- ❖ Biological control
- ❖ Pesticide treatments

Grain managers should carefully monitor the following:

- ❖ Grain quality
- ❖ Grain temperature
- ❖ Insects and insect density
- ❖ Hot spots
- ❖ Mold growth
- ❖ Any "off odor"

### Factors which influence the effectiveness of fumigation

**Sorption** - When a fumigant gas attaches itself to the surface of a grain, it slows diffusion and disrupts penetration of the fumigant through the grain mass.

**Insects** - Grain insect pests and their various developmental stages (egg, larva, pupa and adult) vary in their susceptibility and resistance to fumigants.

**Storage Facility** - A fumigant whether applied initially as a gas, liquid or solid, penetrates the grain and enters the insect in the form of a gas. The "gas tightness" of the storage bin, therefore, greatly influences the retention of the fumigant.

**Temperature** - Temperature influences the distribution of fumigants in grain and affects their ability to kill insects.

**Grain Moisture** - The moisture content of grain also influences the penetration of fumigant gases by altering the rate of sorption.

**Grain Type and Condition** - Various grains have different characteristics that can affect fumigations.



**Air Movement** - Successful fumigation of stored grain requires an understanding of air movement within the grain mass.

**Dosage and time of exposure** - Because fumigants act in the gaseous state, the dosage necessary to kill an insect is related to the concentration of gas surrounding the insect, the insect's respiration rate, which is related partially to temperature, and the time of exposure of the insect to the specific concentration of fumigant

### **SOME OF THE REASONS FOR FUMIGATION FAILURES**

**Insufficient Fumigant:** Efficiency of a fumigant depends on the maintenance of a killing concentration in the grain, any factor that affects gas concentration is important.

**Storage Structure:** A loose structure may not retain fumigants long enough to kill the insects. The depth of the grain in relation to its surface area also affects the efficiency of a fumigant.

**Type of Grain and Dockage:** The kind of grain affects the efficiency of a fumigant in accordance with its sorption quality.

**Moisture:** The moisture content of the grain has a profound effect on the efficiency of a fumigant. As the moisture content increases, a proportionally higher dosage is required.

**Temperature:** During fumigation the gas quickly assumes the temperature of the grain. An increase in temperature results in greater molecular activity of gases, which facilitates the diffusion and penetration of the fumigant.

### **FACTORS AFFECTING AERATION TIME**

**Rate of air exchange:** The exchange rate will be proportional to wind velocity through the area and size and arrangement of the gasses.

**Temperature:** Temperature affects the clearance rate of a fumigant because higher temperatures favor the diffusion of the fumigant and the rate of desorption.

**Sorption and desorption:** The amount of fumigant absorbed by the materials in the area fumigated is referred to as the "load factor." Some commodities are much more sorptive than others. The greater the sorptive capacity of the fumigant and the item fumigated, the longer the desorption process and the greater the aeration time needed.

### **AERATION PROCEDURES**

Plans for aeration should be made before starting the fumigation. Building ventilation Plans for opening doors, windows and ventilators for the initial ventilation are of particular importance.

Aeration should take place for at least 30 minutes to 1 hour before entry and until detectors indicate safe working levels with gas masks.



### **Building ventilation**

At the beginning of the aeration, the building should be entered for only short periods of time. At least two fumigators, wearing previously tested air supply respirators or (SCBA) should enter.

Doors and windows on the floor should be opened first, particularly if none have previously been opened from the outside.

### **Tarpaulins**

When aerating loads under tarps, in buildings, or on still, humid days, an opening should be made by lifting the tarp on the end opposite the blower or source of air and discharging the fumigant with a blower near the outside opening. If blowers or strong cross ventilation is not used, lift tarp at corners and raise as concentration is lowered and finally they can be completely removed.

Respirators or gas masks should be used.

Occupants, other than fumigation operators, should vacate the building before tarps are aerated.

### **Fumigation chambers**

Free gas should be released and commodities aerated immediately following fumigation.

When a fumigation chamber is inside a packing house or any other enclosure where employees are likely to be present, intake and exhaust stacks should be provided. The exhaust stack must lead outside the building. The intake and exhaust stacks should be opened after the fumigation exposure is completed. The normal air circulation equipment in a chamber can be made to conduct air from the chamber to the outside. When a chamber is outside a building, it may be aerated safely by opening the door slightly at the beginning of the aeration period and turning the blower on.

## **FUMIGATION PROCEDURE**

### **Applicant's responsibilities.**



- ❖ Notify official personnel of the intent to fumigate infested grain and the location of carrier to be fumigated.
- ❖ Arrange for a certified applicator to fumigate the infested grain.
- ❖ Verify that the applicator as well as the applicant follows the correct procedures
- ❖ If the grain is aerated prior to shipping (stationary fumigation), arrange for a trained person to remove the placard, aerate and dispose of spent fumigants, using respiratory protection equipment.
- ❖ Contact the consignee for in-transit fumigation and arrange for placards removal and aeration at the point destination.

### **Certified Applicator's Responsibilities**

- ❖ Inspect the involved carrier(s) to determine if it is suitable for fumigation. Fumigate only those carriers deemed suitable.
- ❖ Apply the fumigant in accordance with the labeling requirements.
- ❖ Install warning placards after fumigation exercise
- ❖ Provide copy of fumigant labeling to official personnel and inform them of dosage used.
- ❖ Arrange, in conjunction with the applicant, for a trained person to aerate the carrier to a permissible exposure limit before removing the placards either at point of origin for stationary fumigation or at destination for in-transit fumigation.

### **FUMIGATION MANAGEMENT PLAN**

- ❖ Purpose
- ❖ A Checklist Guide
- ❖ Preliminary Planning and Preparation
- ❖ Personnel
- ❖ Monitoring
- ❖ Sealing Procedures
- ❖ Application Procedures and Fumigation Period
- ❖ Post-Application Operations

### **CHECKLIST GUIDE FOR A FUMIGATION MANAGEMENT PLAN**

#### **RELIMINARY PLANNING AND PREPARATION**

##### **1. What is the purpose of the fumigation?**

Brentwood Properties, Go-down No.11, National Park Eastgate Road Off Mombasa Road. P. O. Box 47358-00100 GPO. Tel: +254-20-2300038/39/40, Off. Cell: +254-725 513580. Email: [info@chemrawea.com](mailto:info@chemrawea.com)



- ❖ Elimination of insect infestation?
- ❖ Elimination of rodent infestation?
- ❖ Plant pest quarantine?

### 2. Determine the type of fumigation

- ❖ Space; tarp, mill, warehouse, food plant.
- ❖ Vehicle; railcar, truck, van, container.
- ❖ Commodity; raw agricultural or processed foods.
- ❖ Grain; vertical silo, farm storage, flat storage.
- ❖ Vessels; ship

3. Fully acquaint yourself with the site and commodity to be treated?

4. What is the fumigant to be used?

5. What are the measured and recorded commodity temperature and moisture?

### PERSONNEL

Confirm in writing that all personnel in and around the area to be fumigated have been notified prior to application of the fumigant. Consider using a checklist each one initials indicating that they have been notified.

- ❖ Instruct all fumigation personnel about the hazards that may be encountered.
- ❖ Instruct all fumigation personnel about the selection of personal protection equipment (PPE) and devices, including detection equipment.
- ❖ Confirm that all personnel are aware of and know how to proceed in case of an emergency situation.
- ❖ Instruct all personnel on how to report any accident and/or incidents related to fumigant exposure.
- ❖ Provide a telephone number for emergency response reporting
- ❖ Instruct all personnel to report to proper authorities any theft of fumigant and/or equipment related to fumigation.
- ❖ Establish a meeting area or rally point for all personnel in case of emergency.

### MONITORING

- ❖ Safety: Keep a log or manual of monitoring records for each fumigation site
- ❖ Efficacy: Gas readings should be taken from within the fumigated structure to insure proper gas concentrations.



### NOTIFICATION

Confirm that all local authorities (fire departments, police departments, etc.) have been notified as per label instructions, local ordinances if applicable, or instructions of the client

### SEALING PROCEDURES

- ❖ Sealing must be complete.
- ❖ Review the previous FMP for previous sealing information.
- ❖ Warning placards must be placed on every possible entrance to the fumigation site.

### APPLICATION PROCEDURES & FUMIGATION PERIOD

- ❖ Plan carefully and apply all fumigants in accordance with the registrants label requirements.
- ❖ Always work with two or more people under the direct supervision of a certified applicator wearing appropriate respirators.
- ❖ Apply fumigant from the outside where appropriate.
- ❖ Provide security when a fumigation site cannot be made secure from entry by unauthorized persons.
- ❖ When entering structures, always follow OSHA rules for confined spaces.
- ❖ Document that the receiver of in-transit fumigation has been notified and is trained to receive commodity under fumigation.

### APPLICATION PROCEDURES

A Fumigation Management Plan (FMP) must be devised for application, aeration and disposal of the fumigant so as to keep to a minimum any exposures to hydrogen phosphide and to help assure adequate control of the insect pests.

### Grain Storage calculations

- ❖ square structures
- ❖ peaked structures
- ❖ triangular prisms
- ❖ irregularly shaped structures
- ❖ cylinders and cones (grain bins)

### Placarding Of Fumigated Areas and Sample Placard

All entrances to the fumigated structure must be placarded. Placards must be made of substantial material that can be expected to withstand adverse weather conditions

### PERSONAL SAFETY

- ❖ Secure the site -- Keep out unauthorized people.





- ❖ Control the temperature –choose a cool, well-ventilated room or building that is insulated or temperature-controlled.
- ❖ Provide adequate lighting -- Pesticide handlers using the facility must be able to see well enough to read pesticide container labeling, notice whether containers are leaking, corroding, or otherwise disintegrating.
- ❖ Inspect for damage -- Inspect containers regularly for tears, splits, breaks, rust, or corrosion.
- ❖ Store volatile products separately -- Volatile pesticides should be separated from other pesticides.
- ❖ Isolate waste products -- store them in a special section of the storage site.
- ❖ Provide clean water -- Each storage site must have an immediate supply of clean water.
- ❖ Prevent contamination -- Only store pesticides, pesticide containers, and pesticide equipment (other than personal protective equipment) in the facility.
- ❖ Keep labels legible -- Store pesticide containers with the label in plain sight.
- ❖ Keep containers closed -- Keep pesticide containers securely closed whenever they are being stored.
- ❖ Use original containers -- Store pesticides in their original containers.
- ❖ Know your inventory -- Keep an up-to-date inventory of stored pesticides.
- ❖ Consider shelf life -- Mark each pesticide container with the date of purchase before it is stored and use older materials first.

### PREVENT PESTICIDE FIRES

Some pesticides are highly flammable while others are not. The labeling of pesticides that require extra precautions will contain a warning statement in either the Physical/Chemical Hazards section or the Storage and Disposal section.

Install fire detection systems in large storage sites, and equip each storage site with a working fire extinguisher approved for all types of fires, including chemical fires.

There are basically four different types or classes of fire extinguishers,

**Class A:** Extinguishers will put out fires involving ordinary combustibles, such as wood and paper.

**Class B:** Extinguishers should be used on fires involving flammable liquids

**Class C:** Extinguishers are suitable for use on electrically energized fires.

**Class D:** Extinguishers are designed for use on flammable metals

### TRANSPORT PESTICIDES SAFELY

- ❖ Carry pesticides in the cargo compartment and never in the passenger compartment.
- ❖ Never carry pesticides near passengers or other goods.
- ❖ All containers should be tightly closed and have legible labels.



- ❖ Secure containers so they will not roll or slide.
- ❖ Protect all containers from moisture and temperature extremes.
- ❖ Never leave a vehicle unattended when the pesticides are unsecured.

### POST-APPLICATION OPERATIONS

- ❖ Provide security when you cannot secure the fumigation site from entry by unauthorized persons during the aeration process.
- ❖ Ventilate and aerate in accordance with structural limitations.
- ❖ Turn on ventilating or aerating fans where appropriate.
- ❖ Use a suitable gas detector before reentry to determine fumigant concentration.
- ❖ Keep written records of monitoring to document completion of aeration.
- ❖ Consider temperature when aerating.
- ❖ Insure aeration is complete before moving vehicle into public roads.
- ❖ Remove warning placards when aeration is complete.
- ❖ Inform client that employees may return to work or otherwise be allowed to re-enter.

### DISPOSAL

Disposals should be done in accordance with the existing law in a licensed landfill. Fumigators should always wear the appropriate personal protective equipment (PPE).

### Appendix

- ❖ Approved Pesticide Label
- ❖ Material safety data sheet (MSDS)
- ❖ Fumigation Management Plan (FMP)
- ❖ Notification of Fumigation and Emergency Response Plan
- ❖ Phosphine fumigation gas monitoring report
- ❖ Official notice of fumigation
- ❖ Site drawing