

**FUMIGATION:**

**PRINCIPLES AND TECHNIQUES**

# **Insect pest management in Stored Products.**

- ❖ **Fumigation**
- ❖ **Controlled Atmosphere**
- ❖ **Residual insecticide Sprays**
- ❖ **Pheromones**
- ❖ **Insect Growth Regulators**
- ❖ **Protectants**  
(Chemicals, inert dusts, natural compounds).



# Fumigation

Fumigation is a method of pest control that completely fills an area with gaseous pesticides—or fumigants—to suffocate or poison the pests within.



**Table 1. Comments on the fumigants of the past and present**

<b>FUMIGANT</b>	<b>COMMENTS</b>
<b>Acrylonitrile</b>	<b>Carcinogen</b>
<b>Ethylene dibromide</b>	<b>Carcinogen</b>
<b>Ethylene oxide</b>	<b>Suspected carcinogen</b>
<b>Carbon tetrachloride</b>	<b>Hepatotoxic</b>
<b>Carbon disulphide</b>	<b>Poor insect toxicity</b>
<b>Ethylene dichloride</b>	<b>Poor insect toxicity</b>
<b>Chloropicrin</b>	<b>Corrosive</b>
<b>HCN</b>	<b>Not permitted for use on food commodities</b>
<b>Methyl bromide</b>	<b>Ozone Depletor</b>
<b>Phosphine</b>	<b>Insect resistance common</b>



# Desirable attributes for a Fumigant

- ❖ Toxicity over short exposure periods
- ❖ High diffusion and penetration potential
- ❖ Insignificant or tolerable amounts of residues
- ❖ Decompose into compounds harmless to the environment.
- ❖ Easy to handle.
- ❖ Easy to detect and monitor.



## CHOICE OF FUMIGANT DEPENDS ON

- ❖ The time available
- ❖ The type of Commodity
- ❖ The Cost and ease of the Application
- ❖ Possible reaction with non-target materials
- ❖ Operational Considerations
- ❖ Market requirements





## Reactions with non-target materials

- ❖ Corrosive effects on metals  
eg.  $\text{PH}_3$  on copper
- ❖ Production of foul/unpleasant odours  
on furnishings, etc.  
eg. MB on rubber products.



# MATERIALS EQUIPMENTS FOR FUMIGATION

- ❖ Adequate quantity of fumigant
- ❖ Fumigation sheeting and sealing materials
- ❖ Fumigant release apparatus-scales, distribution lines, nozzles etc.
- ❖ Safety equipments-gloves, gas mask, canister.
- ❖ Fumigant detection and monitoring devices



## **DOSAGE AND CONCENTRATION**

- **Dosage is the amount of fumigant (formulation) applied.**
- **Concentration is the actual amount of the fumigant present in the airspace in any given part of the enclosure/structure being fumigated at any given time.**

## **SORPTION**

- **The rate of sorption depends on the type of fumigant and commodity and the prevailing temperature.**
- **The sorbed fumigant either reacts with the commodity to form fixed residues (irreversible sorption) or is desorbed again (reversible sorption).**



## SEALING

- Sealing is the hardest and most important part of any fumigation.
- Fumigation has been sometimes described as the 'art of sealing'.
- Fumigants like phosphine can penetrate virtually any sealing materials.

# Fumigation is used

- ❖ as an adjunct to storage hygiene,
- ❖ as a curative treatment and
- ❖ for regulatory purposes





# Fumigation controls/eliminates

- ❖ insects,
- ❖ mites,
- ❖ rodents,
- ❖ snails,
- ❖ microorganisms
- ❖ and nematodes.



## Fumigation Must not be Used When:

- ❖ The enclosure cannot be sealed to an adequate standard.
- ❖ The fumigant cannot be safely aired from the enclosure after the exposure.





## The fumigation enclosure may be

- ❖ metal
- ❖ concrete
- ❖ bricks
- ❖ mud and
- ❖ tarpaulins.



# Vacuum fumigation In air tight/close enclosures





## Places where Fumigation is carried out:

- ❖ In silos
- ❖ In warehouses
- ❖ In freight containers
- ❖ In barges and ships
- ❖ In railway box-cars
- ❖ In specially sealed enclosures (Bubbles)
- ❖ In vaccum chambers
- ❖ Under gas proof-sheets.



# Fumigation of bag stacks

1. Preparation
2. Application of the fumigant and sealing
3. Controls during fumigation
4. Ventilation and release of the store
5. Cleaning up work





## Sealing of sheet to the floor: sand snakes

- ❖ High flexibility (good adaptation to the floor)
- ❖ Sufficient softness (no damage to the sheets)
- ❖ Sufficient weight (to keep the sheet pressed to the floor).

# FUMIGATION TARPAULINS

- ❖ Polyethylene (LDPE)
- ❖ Multi-laminated
- ❖ Polyvinyl chloride (PVC)
  - plain
  - nylon strands inside
  - coated with nylon
- ❖ Rubberised fabric
  - natural/synthetic
  - coated with cotton/nylon/terrycot





## **Fumigation sheets: Specific requirements**

- ❖ **Low weight**
- ❖ **High gas-tightness (including seams)**
- ❖ **Sufficient resistance to tearing**
- ❖ **High resistance to UV light and temperature.**

# Properties of Phosphine

<b>Molecular weight</b>	<b>34</b>
<b>Boiling point</b>	<b>-87</b>
<b>Specific gravity (air=1)</b>	<b>1.2</b>
<b>Vapour Pressure</b>	<b>38.5</b>
<b>Flammability limits (%V/V)</b>	<b>1.8 (27g/m<sup>3</sup>)</b>
<b>Solubility</b>	<b>0.35</b>





## Essential requirements for Aluminium phosphide formulations as per Insecticides Act, 1968

### 1. Composition

Aluminium phosphide (a.i)	56% w/w
Ammonium carbonate	5
Aluminium stearate	2.5
Aluminium oxide/hydroxide	14.5
Urea	18.0
Graphite	1.5
Paraffin wax	2.5

2. Shelf life 2 years

3. Packing Specifications as per IS 8190 Part IV 1988

4. Other requirements as per IS 6438-1980

## PHOSPHINE IS THE FUMIGANT OF CHOICE

- ❖ When a commodity is required > 7 days.
- ❖ When Khapra beetle are present and use of MeBr is not mandatory.
- ❖ When oilseeds, cakes and meals must be treated.
- ❖ Where germination is important.
- ❖ Where commodities have been treated previously with MeBr.
- ❖ Where taint may be a problem if MeBr is used.



## PHOSPHINE SHOULD NOT BE USED

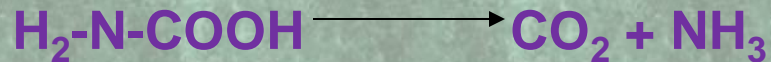
- ❖ Where resistance is known to exist.
- ❖ At low temperatures below 15° C.
- ❖ Where a rapid treatment (<7 days) is required.
- ❖ In areas immediately adjacent to workspaces and habitations.
- ❖ Where there is no trained, qualified and properly protected fumigation team.

# Chemical reactions

Aluminum phosphide tablets or pellets reacts with moisture in the air to release phosphine (PH<sub>3</sub>) gas.



Ammonium carbonate releases ammonia as a warning gas





## AIP dosage Recommended by PPQS

<u>Commodity</u>	<u>Dosage</u>	<u>Exposure period</u>
Whole cereals, millets, Seed grains, pulses, dry fruits, nuts and spices	3 tablets/t or 150g/100m <sup>3</sup>	minimum 5 days 7 for Sitophilus 14 for Khapra
Milled products (flour, suji) deoiled cakes, rice bran, animal & poultry feed, split pulses and other processed foods.	3 tablets/t	5 days
Empty godowns.	14 tablets/1000ft <sup>3</sup> or 150g/100m <sup>3</sup>	3 days

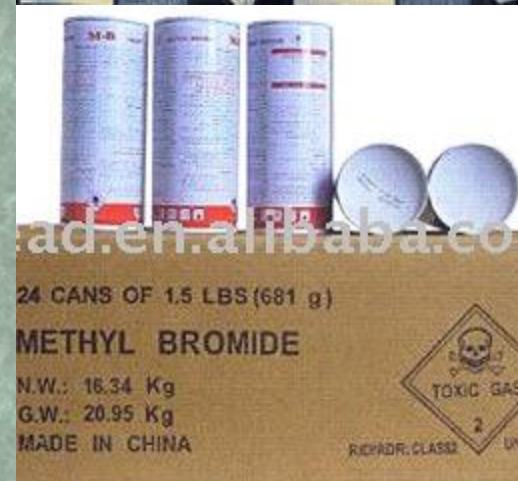
## LOCAL (SPOT) FUMIGANTS FOR MILLS

1. Acrylonitrile 1: Carbon Tetrachloride 2 (V/V)
  2. Ethylene Dibromide 1: Ethylene Dichloride 1 : Carbon Tetrachloride
  3. Ethylene Dichloride 3: Carbon Tetrachloride 1
  4. Ethylene Dibromide 7: Methyl bromide 3
- 
1. Chloropicrin



## PROPERTIES OF METHYL BROMIDE

Molecular weight	95
Boiling point ( $^{\circ}$ C)	3.6
Specific volume ( $m^3/Kg$ )	0.256
Specific gravity of gas (air =1)	3.4
Vapour pressure at 25 $^{\circ}$ C (mm Hg)	1824
Flammability limits in air (% v/v)	10-16
Solubility in water at 25 $^{\circ}$ C (g/L)	13.4
Volume per Kg (ml)	577.4



## Minimum Effective dosages of methyl bromide for a 24 H treatment

Sorption	Commodity	Dosage (g/m <sup>3</sup> )
Low	Whole cereals (except paddy, pulses, spices shelled peanuts, sesame, cotton seed, dry ginger, arecanut, tamarind pulp)	16
High	Paddy, wheat flour, semolina, many split pulses	32-48
Very high	Split green gram and lentil, Bengal-gram flour, oil cakes and fish meal	48-96



## MeBr dosage Recommended by PPQS

Commodity	Dosage(g/m <sup>3</sup> )	Exposure (hr) period
Whole cereals, millets, pulses, tapioca chips	24	24-48
Milled products (flour, Maida, suji) oil seeds, cakes, dry fish, skimmed milk powder.	24-32	24-28
Dry fruits, spices, oilseeds.	24-32	24-48

# Merits and demerits of MeBr

- ❖ Refillable cylinders are expensive to transport
- ❖ Requires special equipment accessories and skill
- ❖ Suitable for vacuum fumigation
- ❖ Rapidly toxic & effective even at lower temperatures
- ❖ Sorption occurs, may cause malodors or bromide residues and loss of viability.
- ❖ Dangerous, acute and chronic poisoning with delayed symptoms.
- ❖ Ozone depletor.



# ETHYLENE OXIDE

Microbial sterilent



## Dichlorvos (DDVP)

Trade Name	Nuvan, Vapona
Chemical name	1,2 dichlorovinyl dimethyl phosphine
Molecular weight	221
Boiling Point (0 C)	120
Vapour pressure (mm Hg)	0.025
Solubility in water (g/L)	10
Flammability	Noninflammable
Corrosiveness	Corrodes, iron, mild steel
Status	Carcinogen





# **DETECTION AND MONITORING OF FUMIGANTS**

**If you are not monitoring, you  
are not  
fumigating!**



# NEED FOR DETECTION & MONITORING OF FUMIGANTS



Three major problems for the fumigators.

- The pest may not be killed.
- Second, loss of the fumigant to the outside of the structure means a loss of a fairly expensive pesticide.
- Third, the ability of fumigants to move through the smallest of cracks.

# MONITORING FOR HEALTH AND SAFETY

- Health and safety monitoring
  - ✓ 0.3 ppm (0.0004 g/m<sup>3</sup> or 0.42 mg/m<sup>3</sup>) for **phosphine**.
  - ✓ 5.0 ppm (0.02 g/m<sup>3</sup> or 19.4 mg/m<sup>3</sup>) for **methyl bromide**.



# PHOSPHINE DETECTOR TUBES



- filled with a solid material gel that has been impregnated with an indicator chemical.

# UPL Gas Detector Tubes







# PHOSPHINE DETECTOR STRIPS

# PORTA SENS GAS DETECTOR





# FUMISCOPE





# DANGER/PELIGRO

- Structure And/Or Commodity Under Fumigation -  
DO NOT ENTER/NO ENTRE



## PHOSPHINE GAS



This Enclosure Is Being Fumigated With

EPM

- |   |   |   |   |
|---|---|---|---|
| <input type="checkbox"/> 2299-1 FUMITOXIN <sup>®</sup> TABLETS      | <input type="checkbox"/> 2299-2 SALT HUMITOXIN <sup>®</sup> PELLETS | <input type="checkbox"/> 2299-6 CELESTROPS                        | <input type="checkbox"/> 2299-9 PHOSTOXIN <sup>®</sup> TABLE PREPACKS |
| <input type="checkbox"/> 2299-3 SPOD FUMITOXIN <sup>®</sup> TABLETS | <input type="checkbox"/> 2299-4 PHOSTOXIN <sup>®</sup> TABLETS      | <input type="checkbox"/> 2299-7 SPOD FUMIGANT                     | <input type="checkbox"/> 2299-10 DETA FUMEX                           |
| <input type="checkbox"/> 2299-2 FUMITOXIN <sup>®</sup> PELLETS      | <input type="checkbox"/> 2299-5 PHOSTOXIN <sup>®</sup> PELLETS      | <input type="checkbox"/> 2299-8 PHOSTOXIN <sup>®</sup> TABLE ROPE | <input type="checkbox"/> 2299-11 MASTOXIN <sup>®</sup> GRANULES       |

THIS SIGN MAY ONLY BE REMOVED BY A CERTIFIED APPLICATOR OR A PERSON WITH DOCUMENTED TRAINING AFTER THE STRUCTURE AND/OR COMMODITY IS COMPLETELY AERATED (CONTAINS 0.3 PPM OR LESS OF PHOSPHINE GAS). IF INCOMPLETELY AERATED COMMODITY IS TRANSFERRED TO A NEW STRUCTURE, THE NEW STRUCTURE MUST ALSO BE PLACARDED IF IT CONTAINS MORE THAN 0.3 PPM PHOSPHINE. WORKERS' EXPOSURE DURING THIS TRANSFER MUST NOT EXCEED ALLOWABLE LIMITS.

FUMIGATION PERFORMED BY:

Name \_\_\_\_\_

Address \_\_\_\_\_

Russel Bowen, Fesco-X Company  
Mason, IL, CO 7827 1-800-895-7951  
Night 573-450-8083

EMERGENCY TELEPHONE # \_\_\_\_\_

Day \_\_\_\_\_

Night \_\_\_\_\_

FOR HUMAN OR ANIMAL  
EMERGENCIES CALL 1-800-308-4358



DATE OF FUMIGATION:

Start \_\_\_\_\_

Finish \_\_\_\_\_

ALL OTHER CHEMICAL EMERGENCIES  
CALL CHEMTREC 1-800-424-9300

FORM NO. 11276 (Revised 2007) (P. 207)

1411010010

PLACARDING



# RESPIRATORY APPARATUS



A full-face canister gas mask can be used at gas concentrations from 0.3 ppm to 15 ppm

# RESPIRATORY APPARATUS.....

**GAS MASK WITH CANISTERS**



**GAS MASK**



Use specific canisters designed for the gas



# AERATION PROCESS

- Plan the aeration process to minimize the gas levels above the TLV reaching unprotected persons.
- Open only few doors or windows at first, and turn on a limited number of ventilation fans.



# **AERATION PROCESS.....**

Check the fumigation levels in

- ✓ Basements where there is poor ventilation.
- ✓ Enclosed areas such as bins, washrooms and offices.



## MILD EXPOSURE OF PH<sub>3</sub> BY INHALATION CAUSES ....

- ✓ malaise (indefinite feeling of sickness),
- ✓ ringing in the ears,
- ✓ fatigue,
- ✓ nausea
- ✓ and pressure in the chest, which is relieved by removal to fresh air.

## MODERATE POISONING CAUSES...

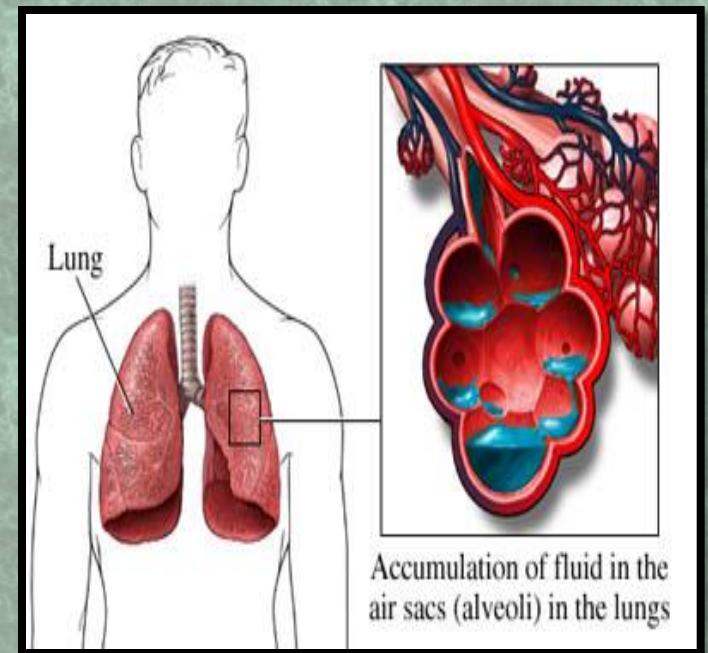
- ✓ weakness,
- ✓ vomiting,
- ✓ pain just above the stomach,
- ✓ chest pain,
- ✓ diarrhoea and
- ✓ dyspnea (difficulty in breathing).



# Symptoms of severe poisoning

may occur within a few hours to several days

- ✓ resulting in pulmonary edema (fluid in lungs) and may lead to dizziness,
- ✓ cyanosis (blue or purple skin color),
- ✓ unconsciousness, and death.



THANK YOU