



USAID
FROM THE AMERICAN PEOPLE

AGRICULTURAL COMMODITY PROTECTION BY PHOSPHINE FUMIGATION PROGRAMMATIC ENVIRONMENTAL ASSESSMENT TOOLS ANNEX



NOVEMBER 2013

This publication was produced for review by the United States Agency for International Development (USAID). It was prepared under USAID's Global Environmental Management Support (GEMS) project.

Cover photos: Phosphine fumigation monitoring equipment (top left), DIMEGSA Pest Control staff in Guatemala (top right), USAID food commodities stored in a warehouse (bottom).

COMMODITY PROTECTION BY PHOSPHINE FUMIGATION IN USAID FOOD AID PROGRAMS PROGRAMMATIC ENVIRONMENTAL ASSESSMENT TOOLS ANNEX

Updated December 2015

(original NOVEMBER 2013)

Contract No.: AID-OAA-M-11-00021

Prepared for:

Office of Food for Peace

Bureau for Democracy, Conflict and Humanitarian Assistance

United States Agency for International Development

Prepared under:

The Global Environmental Management Support Project (GEMS), Award Number AID-OAA-M-11-00021. The Cadmus Group, Inc., prime contractor (www.cadmusgroup.com). Sun Mountain International, principal partner (www.smtn.org).



DISCLAIMER

Until and unless this document is approved by USAID as a 22 CFR 216 Programmatic Environmental Assessment, the contents may not necessarily reflect the views of the United States Agency for International Development or the United States Government.

TABLE OF CONTENTS

ANNEX T-1: GUIDE: FUMIGATION COMPLIANCE GUIDANCE FOR USAID PARTNERS.....	1
ANNEX T-2: TEMPLATE: FOOD COMMODITY PROTECTION PERSUAP FOR PHOSPHINE FUMIGATION & CONTACT PESTICIDES.....	4
ANNEX T-3: TEMPLATE: FUMIGATION MANAGEMENT PLAN (FMP) FOR PHOSPHINE FUMIGATION OF FOOD COMMODITIES IN SHEETED STACKS.....	18
ANNEX T-4: TEMPLATE: PHOSPHINE FUMIGATION SERVICES QUOTATION REQUEST.....	35
ANNEX T-5: TEMPLATE: PHOSPHINE FUMIGATION SERVICES CONTRACT.....	37
ANNEX T-6: TEMPLATE: IPM PRACTICES & INSPECTION CHECKLIST FOR USAID-FUNDED COMMODITIES AND WAREHOUSES.....	39
ANNEX T-7: REFERENCE: FUMIGATION AND CONTACT PESTICIDE BEST MANAGEMENT PRACTICES.....	41
ANNEX T-8: REFERENCE: ALUMINUM PHOSPHIDE MSDS & PHOSPHINE FACTSHEET.....	54
ANNEX T-9: REFERENCE: PHOSPHINE GAS MONITORING EQUIPMENT & RESPIRATORY PROTECTION.....	71
ANNEX T-10: REFERENCE: PHOSPHINE GAS EXPOSURE FIRST AID.....	79
ANNEX T-11: REFERENCE: ECONOMICALLY IMPORTANT STORED-PRODUCT INSECT PESTS OF GRAIN AND GRAIN PRODUCTS.....	83
ANNEX T-12: REFERENCE: DECIDING WHEN TO FUMIGATE.....	87
ANNEX T-13: REFERENCE: TRAINING AND EDUCATION MATERIALS ON PHOSPHINE FUMIGATION AND FOOD PROTECTION.....	92

ANNEX T-I GUIDE: FUMIGATION COMPLIANCE GUIDANCE FOR USAID PARTNERS

With the approval of the “Commodity Protection in USAID Food Assistance Programs by Phosphine Fumigation” Programmatic Environmental Assessment (“Fumigation PEA”), USAID for the first time will have uniform, mandatory environmental, health and safety requirements regarding phosphine of food commodities.

This Annex guides USAID implementing partners in complying with these requirements. **Partners that follow the instructions in this annex, use the templates provided in other “T” Annexes, and follow through on implementation and reporting as specified herein will satisfy the requirements established by the PEA. In areas where Partners are unable to meet the implementation and reporting conditions described herein, they must request an exception from USAID. All substantive changes must be approved.**

Note that this document assumes knowledge of USAID program implementation and management, including the basics of environmental compliance for USAID food assistance activities.

OVERVIEW OF FOOD ASSISTANCE PROGRAM FUMIGATION COMPLIANCE

USAID partner programs that contract for phosphide fumigation of food commodities must assure that such fumigation:

- Complies with the mitigation measures set out in section 5.3 of the PEA (see summary box at right).
- Report on compliance with these requirements.
- Have formal authorization under USAID’s environmental procedures to contract for (generally, “support”) such fumigation.

THE FUMIGATION PERSUAP

A program-specific Pesticide Evaluation Report and Safer Use Action Plan (PERSUAP)¹ for phosphine fumigation is the mechanism by which all three of these requirements are addressed:

- The phosphine fumigation PERSUAP, when approved by USAID, authorizes phosphine fumigation of food commodities for the subject program.
- The PERSUAP authorizes such fumigation subject to the condition that the mitigation measures (safer use requirements) set out in section 5.3 of the PEA are implemented. These conditions are set out in the safer use action plan (SUAP) portion of the PERSUAP.

In summary, the SUAP must establish the following compliance requirements:

Key “safer fumigation” requirements per this PEA.

Fumigation Services RFQs and contracts require conformity with acceptable fumigation practices per annex T-6, including:

- Required use of canister respirators or self-contained breathing apparatus (SCBA)
- Required hazard & efficacy monitoring
- Required maintenance of an exclusion zone for duration of fumigation event (7-10 days)

Each fumigation event must have a fumigation management plan (FMP) conforming to these practices

USAID partners shall enforce these requirements and take corrective actions as required.

¹ PERSUAPs are 22 CFR 216 Initial Environmental Examination (IEE) amendments. They fulfill the analysis and safeguard requirements established by 22 CFR 216.3(b) for any use of pesticides in a USAID-funded or USAID-managed activity.

1. Implementation of good-housekeeping IPM Measures that are essential complements to fumigation per PEA Annex T-6
 2. Implementation of a **Fumigation Management Plan (FMP)** for each fumigation event. The FMP must substantively conform to the plan provided as Fumigation PEA Annex T-3, EXCEPT as specifically noted. The FMP requires, inter alia, (a) use of canister respirators or self-contained breathing apparatus; (b) monitoring phosphine gas concentrations for hazard and efficacy; and (c) maintenance of an exclusion zone for duration of fumigation event (7-10 days),
 3. Completion of the FMP should be included in contracts issued by USAID partners. The **FMP should be provided by the fumigator, aka the fumigation contractor. If the PVO conducts the fumigation (note that most PVOs do not have the in-house expertise and certifications required to conduct fumigations), the PVO is responsible for completing the FMP. Ultimately, the PVO is responsible that an FMP is completed and that a copy remains on site for two years.**
 4. Storage and Transport of Aluminum Phosphide, if under program control, will substantively conform to contact pesticide best practices as set out in Fumigation PEA Annex T-7, except as specifically noted.
 5. Monitoring and Corrective Actions. Program will actively monitor compliance with above-listed conditions and undertake corrective actions as needed.
- Similarly, the PERSUAP authorizes the use of specific contact (residual) pesticides as complements to fumigation, on the condition that their use substantively conform to contact pesticide best practices as set out in Fumigation PEA Annex T-7, EXCEPT as specifically noted.
 - Finally, SUAP also serves as a fumigation compliance tracking and reporting tool; partners must report annually on fumigation compliance as part of their Environmental Status Report.
 - Add requirement for completion of an FMP in contract; i.e., FMP must be completed and a copy must remain on-site.

PARTNER PERSUAP DEVELOPMENT RESPONSIBILITY & PROVIDED TEMPLATE

Development and submission of the PERSUAP is the responsibility of the USAID partner. A template fumigation PERSUAP is provided as Annex T-2 to this Fumigation PEA. This template:

1. satisfies the requirements of the PEA;
2. should very substantially reduce USAID partner effort required to prepare and submit an appropriate PERSUAP; and
3. serves as a mandatory fumigation compliance tracking and reporting template that must be submitted with the program's annual environmental status report.

Note: Formally, the PERSUAP is an amendment to the program's IEE. As such, it must be cleared by the country or regional mission and by the DCHA Bureau Environmental Officer in Washington

TIMING OF PERSUAP SUBMISSION AND APPROVAL

The PERSUAP need not be part of a new the program's IEE. But it must be approved and in place before the program undertakes phosphine fumigation of food commodities.

Following submission and approval, the USAID partner must then comply with the SUAP, and submit the updated SUAP annually to USAID as a part of the program's Environmental Status Report.

RELATIONSHIP OF THE SUAP TO THE EMMP

Food Assistance Programs IEEs require that programs develop an EMMP (Environmental Mitigation and Monitoring Plan) detailing how environmental mitigation and management required by the IEE will be implemented. The SUAP satisfies the requirement of an EMMP for fumigation activities. The overall program EMMP should simply incorporate the fumigation SUAP by reference.

ANNEX T-2

TEMPLATE: FOOD COMMODITY PROTECTION PERSUAP FOR PHOSPHINE FUMIGATION & CONTACT PESTICIDES

The following is a fill-in template for a Pesticide Evaluation Report and Safer Use Action Plan (PERSUAP) for Commodity Protection by Phosphine Fumigation & Contact Pesticides, and one of the tools of the Fumigation PEA.

New Food Assistance Programs supporting phosphine fumigation **MUST** have an approved Fumigation PERSUAP in place **BEFORE** supporting phosphine fumigation. If contact (residual) pesticides are to be used as a complement to fumigation, the Fumigation PERSUAP must also cover their use. (The sole exception is if such the program has another PERSUAP, e.g. for use of pesticides in agricultural production, and contact pesticide is covered by this PERSUAP.)

For additional information, refer to Annex T-1 of the Fumigation PEA, which describes the purpose of the PERSUAP and summarizes the requirements it establishes.

The template is highly detailed with respect to Aluminum Phosphide. It is necessarily less detailed for contact (residual) pesticides, as there are a large number of potential products that may be used. Examples of simple PERSUAPs in USAID's database of 22 CFR 216 documentation can provide guidance as to how to fill in the various fields.

In areas where Partners are unable to meet the implementation and reporting conditions described herein, they must request an exception from USAID. All substantive changes must be approved.

Step 1: click: <http://gemini.info.usaid.gov/egat/envcomp/>

Step 2: Click on the "Advanced Search" tab

Step 3: in the first field "Source Document Text Search" enter the name of the contact pesticide that you seek to use.

Step 4: Click on "search" and then on the "PDF" link to view the resulting documents.

This is a **Food Commodity Protection PERSUAP template**. **Instructions:** Review full text of document. Fill in or replace all **green-highlighted** fields. If a contact pesticide is to be used, include/fill-in **yellow-highlighted** fields; otherwise delete. Alter any provided text not applicable to your program; however, be advised that substantive changes to safer use measures may not be approved by USAID. If you wish to make a substantive change to this template you must request an exception from USAID, **Delete this box & clear highlighting before submitting to USAID.**

**USAID INITIAL ENVIRONMENTAL EXAMINATION- AMENDMENT FACESHEET
PESTICIDE EVALUATION PLAN AND SAFER USE ACTION PLAN (PERSUAP) FOR
COMMODITY PROTECTION BY PHOSPHINE FUMIGATION & CONTACT PESTICIDES**

Activity/Project Title: INSERT TITLE	
Contract/Award Name(s) & Number(s) (if known) : Insert contract/ award name and number	
Geographic Location: Insert implementation country and region e.g. Ethiopia/Africa	
Operating Unit(s):	
IEE Amendment (Y/N): YES	DCN and Date of Original IEE: insert PEA clearance date
	Env Compl Database link: insert link to PEA on ECD http://semini.info.usaid.gov/ewat/envcomp/
Annual Funding Amount (optional field):	Life of project Amount:
Implementation Start/End:	
IEE Prepared by: Insert name, organization, contact info	
Date Prepared: Updated September 2015	PEA Expiration Date (if any): September 2020
Implementing Partner(s):	
Recommended Threshold Determination: <input checked="" type="checkbox"/> Categorical Exclusion <input type="checkbox"/> Negative Determination <input checked="" type="checkbox"/> With Conditions	<input type="checkbox"/> Positive Determination <input type="checkbox"/> Deferral

Note: SUAP requirements (see sections 6 and 7 of this PERSUAP Template) will be incorporated as needed into program Detailed Implementation Plan (DIP) and Budget

SUMMARY OF FINDINGS

Phosphine fumigation of food commodities **and complementary use of the contact pesticide** **[insert product name]** **in and around food commodity warehouses** for the **XXX** Program is approved subject to compliance with the Safer Use Action Plan (SUAP) that constitutes sections 6 and 7 of the PERSUAP Template. The SUAP imposes the mitigation requirements (safer use conditions) established by the Programmatic Environmental Assessment “Phosphine Fumigation of Stored Agricultural Commodity.”

LIST OF CONDITIONS

Condition 1: A **Fumigation Management Plan (FMP)** must describe the fumigation process, including for fumigant pesticide use, storage, transport and disposal. The FMP and the actual fumigation process will substantively conform to the plan provided as Tool T-3 (Template of the FMP) of the Fumigation PEA. This FMP must include the following details on the fumigation equipment:

- 1a). Gas monitoring Equipment:** Brand name, model and type of phosphine gas monitoring equipment (electrochemical, photo-ionization or tube type)
- 1b) Personal Protection Equipment:** including gas canister masks or self-contained breathing apparatus
- 1c) Gas impermeable tarps:** resistant to UV light and tearing along both length and width, and impermeable to phosphine gas

The **TOPS Warehouse Safety [Guidelines](#) and [Posters](#)** detailing the safety measures to take before, during and after fumigation, as well as proper disposal and cleanup procedures after fumigation can also be consulted.

Condition 2: Any additional **Contact Pesticide(s)** used in warehouse commodity protection must be limited to the pesticide(s) authorized by the PERSUAP and should substantively conform to contact pesticide best practices as set out in Fumigation PEA [Annex T-6](#) on “IPM PRACTICES & INSPECTION CHECKLIST FOR USAID-FUNDED COMMODITIES AND WAREHOUSES”. The PERSUAP will also include information on the safe use measures and personal protection equipment used in the application of the contact pesticide(s), as well as contact pesticide storage, transport and disposal.

Condition 3: Good Housekeeping and IPM Measures. The implementing partner must fully implement the daily/weekly warehouse and commodities inspection checklist ([Annex T- 6](#) on IPM PRACTICES) and take maintenance/corrective actions specified. Compliance with this checklist implements a set of IPM measures that are essential complements to fumigation. The implementing partner will also only purchase commodity that is at 13% or less moisture and distribute stocks as quickly as possible in order to ensure full protection against fungal growth, since fungal growth and mycotoxin production cannot be completely controlled by phosphine fumigation.

Condition 4: Fumigation Contract Language When using a 3rd-Party Fumigation Service Provider, the provided model RFQ and contract (or substantive equivalent) will be used to procure fumigation services and proposals/quotes will be evaluated based on ability to comply with specified safer use practices, including the procurement and use of gas monitoring equipment, fumigation and contact pesticide PPE as well as gas impermeable tarps meeting specified requirements.

Condition 5: The implementing partner will actively **monitor compliance** with the above-listed conditions and undertake **corrective actions** as needed.

APPROVAL OF ENVIRONMENTAL ACTION RECOMMENDED FOR:

Fumigation PERSUAP for [Name of Program]

A. CLEARANCE

_____	Date _____
Mission Environmental Officer	
_____	Date _____
Regional Environmental Advisor/Officer*	
_____	Date _____
Mission Director	
_____	Date _____
A/COR	
_____	Date _____
Office Director (as applicable)	

B. CONCURRENCE

_____	Date _____
Bureau Environmental Office ¹	

Accepted:

Not Accepted:

*Mandatory for non-presence countries

¹ Refer to the appropriate office: http://www.usaid.gov/our_work/environment/compliance/environmental-compliance-officers

USAID INITIAL ENVIRONMENTAL EXAMINATION- AMENDMENT Pesticide Evaluation Plan and Safer Use Action Plan (PERSUAP) for Commodity Protection by Phosphine Fumigation & Contact Pesticides

USAID PROGRAM DATA

Program Name: Insert
Awardee: insert organization
Country/Region: insert country/region
Period of Performance: X years (start date – end date)

I. PURPOSE AND SCOPE OF PERSUAP

Upon approval, this Fumigation PERSUAP, submitted as an amendment to the [insert program name] IEE will authorize phosphine fumigation of [insert program name] food commodities. This PERSUAP will also authorize complementary use of the contact pesticide(s) [insert product names] in and around empty warehouses for these commodities. Fumigation and contact pesticide use is authorized subject to strict safer use conditions. As described herein, use of fumigation and contact pesticide is necessary for successful program implementation.

Formally, approval of this PERSUAP will assign a **negative determination** to phosphine fumigation and use of the contact pesticide [insert product name], subject to the **condition** that the Safer Use Action Plan provided as Sections 6 and 7 of the PERSUAP Template, is fully implemented.

This PERSUAP satisfies the requirements of 22 CFR 216.3(b) (USAID Pesticide Procedures) and puts in place the safer use requirements (mitigation measures) established by the USAID Programmatic Environmental Assessment “Phosphine Fumigation of Stored Agricultural Commodity” (Henceforth the “[Fumigation PEA](#).”)²

2. PROGRAM DESCRIPTION

Provide a BRIEF (not more than 1 or 2 paragraph description) of the program

3. COMMODITY PROTECTION NEEDS

List the food commodities being managed. Provide general information about the length of time commodities are typically stored in primary and secondary warehouses. List known pest problems and succinctly describe consequences of failure to adequately control commodity pests. **Do not spend more than 1 or 2 paragraphs on this section.**

The Fumigation PEA establishes that food commodity protection by fumigation addresses food commodity protection needs that can rarely be completely replaced by other methods. It also establishes that the complementary use of contact pesticide in and around warehouses is usually an integral part of the fumigation process to kill insects escaping fumigation and prevent re-infestation of the commodity.

² Approved (insert date). Available on: http://www.usaidgems.org/Documents/FumigationPEA/FumigationPEAFeb24_2014.pdf

4. PROPOSED PESTICIDE(S).

This PERSUAP requests approval to use aluminum phosphide³ as an indoor fumigant at storage facilities for the following commodities: **insert commodity names**. Use is requested of both pellet and tablet formulations with 55-57% active ingredient.

This PERSUAP also requests approval to use the contact pesticide **insert product name** as a complement to fumigation in and around food commodity warehouses.

5. FACTOR ANALYSIS PER 22 CFR 216.3(B)(1)(I)(A THROUGH L)

This section provides the 12-factor analysis required by 22 CFR 216.3(b) to allow USAID to make a determination as to whether to permit use of a proposed pesticide and to establish appropriate safer use conditions.

Separate Factor Analyses are provided for (1) Aluminum Phosphide and (2) **insert name of contact pesticide**.

FACTOR ANALYSIS FOR ALUMINUM PHOSPHIDE

ANALYSIS FACTOR	ANALYSIS
<p>(a) USEPA registration status of the proposed pesticide.</p> <p>Partner country registration status</p>	<p>Aluminum phosphide is an inorganic phosphide registered in the U.S. under CAS Number 20859-73-8 with U.S. EPA PC Code 066501. Aluminum phosphide is a Restricted Use Pesticide (RUP) so in the US may be purchased and used only by certified applicators. It is in EPA's toxicity Class I, and products containing it must bear the signal word DANGER. In contact with water, it produces a toxic gas <i>hydrogen phosphide</i>. Aluminum phosphide is widely used for fumigation of food commodities and structures.</p> <p>Provide analogous partner country registration information and any restrictions established by this registration.</p>
<p>(b) Basis for selection of the pesticide</p>	<p>The selection of aluminum phosphide is based on: efficacy against pests of stored grains, low cost, availability in country, and registration in country.</p> <p>If used in accordance with safeguards, aluminum phosphide is not expected to have adverse environmental impacts; this is also a factor in its selection.</p> <p>Efficacy and the effectiveness of use safeguards have already been assessed extensively in the Fumigation PEA and thus are not addressed further here.</p> <p>The selection was also based on the availability of a qualified professional service provider for phosphine fumigation.</p>
<p>(c) Extent to which the proposed pesticide use is, or</p>	<p>The Safer Use Action Plan requires compliance with Fumigation PEA Annex T-6 on IPM PRACTICES. This checklist contains good-housekeeping based Integrated Pest Management (IPM) practices that are essential complements to fumigation, including</p>

³ It should be noted here that Phosphine Fumigation refers to fumigation with aluminum phosphide

<p>could be, part of an IPM program</p>	<p>daily sanitation of the warehouse; clearing warehouse surroundings of weeds on a weekly basis; daily inspections for pests; and strictly adhering to the first in first out (FIFO) rule to minimize the storage time of the commodities in the warehouse.</p> <p>(List any additional IPM food commodity protection practices to which the program is committing.)</p>
<p>(d) Proposed method or methods of application, including the availability of application and safety equipment</p>	<p>Aluminum phosphide will be used for indoor fumigation of warehoused food commodities in sheeted stacks only. It should be noted that the uses specified for Aluminum phosphide in this PERSUAP DO NOT cover outdoor fumigation and soil fumigation.</p> <p>Via the Fumigation Management Plan, the SUAP requires that fumigation follow acceptable technical practices specified in Annex T-7 on “FUMIGATION AND CONTACT PESTICIDE BEST MANAGEMENT PRACTICES” of the Fumigation PEA. These include, among others, use of appropriate personal protection equipment, including respirators, maintenance of an exclusion zone that only fumigation personnel can enter for duration of the fumigation (7-10 days or more)⁴, and phosphine gas monitoring for efficacy and hazard.</p> <p>Note if the program’s fumigation services provider will provide PPE and monitoring equipment, or if the program will do so.</p>
<p>(e) Any acute and long-term toxicological hazards, either human or environmental, associated with the proposed use, and measures available to minimize such hazards.</p>	<p>The potential toxicological effects of aluminum phosphide are well covered by EXTOXNET, and Extension Toxicology Network.* The Fumigation PEA includes details of acute human health exposure and potential impacts to fumigators, other on-site workers, visitors, nearby residents and beneficiaries. In summary:</p> <ul style="list-style-type: none"> • The main routes of exposure to aluminum phosphide are through inadvertent ingestion or inhalation during fumigation of the highly toxic gas. • Symptoms of mild to moderate acute aluminum phosphide toxicity include nausea, abdominal pains, tightness in chest, excitement, restlessness, agitation and chills. Symptoms of more severe toxicity include diarrhea, cyanosis, difficulty breathing, pulmonary edema, respiratory failure, tachycardia and hypotension, dizziness and or death. • The available evidence for reproductive effects in animals suggests that they are not likely in humans under normal conditions. No evidence is available to support teratogenic effects in humans or to support the ability of aluminum phosphide to cause mutations or increase mutation rates. • There is no evidence of aluminum phosphide having a negative impact on soil or ground water. It breaks down spontaneously in the presence of water to form a gaseous product, thus is non-persistent and non-mobile in soil and poses no risk to groundwater. For the same reasons, it is unlikely that aluminum phosphide or phosphine will contaminate surface waters. • The USEPA has determined that uses of aluminum phosphide will not generally cause unreasonable adverse effects to humans or the environment if used in

⁴ There is some controversy over the optimal exposition time to respect from fumigating the warehouse to aerating it after the phosphine gas has dissipated, for efficient pest control. For any clarifications, please contact the DCHA BEO (eclesceri@usaid.gov)

	<p>accordance with the approved use directions and revised precautionary statements prescribed by the registration standard. Requirements for acute toxicity data have been waived because of the well-known extreme inhalation toxicity of phosphine gas, which it generates. Accordingly, aluminum phosphide has been placed in toxicity category I, the highest toxicity category.</p> <p>Tolerances have been established for raw agricultural commodities at a level of 0.1 ppm (40 CFR 180.225); processed foods 0.01 ppm (21 CFR 193.20); and animal feeds 0.1 ppm (40 CFR 561.40). Finished food and feed must be held and aerated 48 hours prior to being offered to the consumer.</p> <p>Via the Fumigation Management Plan, the SUAP requires that fumigation follow acceptable technical practices specified in Annex T-7 on BEST MANAGEMENT PRACTICES of the Fumigation PEA. These include, among others, use of appropriate personal protection equipment, including respirators, maintenance of an exclusion zone that only fumigation personnel can enter for duration of the fumigation (7-10 days or more), and phosphine gas monitoring for efficacy and hazard.</p> <p>*http://pmep.cce.cornell.edu/profiles/extoxnet/24d-captan/aluminum-phosphide-ext.html</p>
<p>(f) Effectiveness of the requested pesticide for the proposed use.</p>	<p>Aluminum Phosphide is registered by US EPA as stored grain pesticide. It is considered the most effective method of controlling stored commodity pests, especially when used in an IPM framework, as described above in (c).</p> <p>In-country experience is that this fumigant is very effective in killing the intended targets noted in section 3 within the prescribed seven to ten day fumigation time.</p> <p>Describe any resistance reported or known to you. If none, "We are not aware of any instances of resistance to aluminum phosphide by the intended target pests."</p>
<p>(g) Compatibility of the proposed pesticide use with target and non-target ecosystems.</p>	<p>As an indoor fumigant, aluminum phosphide presents risks to fumigators and those working or living nearby, but there is not a "target ecosystem" of concern.</p> <p>Indoor use, non-persistence and non-mobility in soil, negligible potential to contaminate surface waters, and a short half-life in air of ~5 hrs (daylight) mean that aluminum phosphide has essentially no interaction with or impact on non-target ecosystems.</p>
<p>(h) The conditions under which the pesticide is to be used, including climate, flora, fauna, geography, hydrology, and soils</p>	<p>As noted, aluminum phosphide will be used solely for indoor fumigation of warehoused food commodities: Briefly describe the warehouse(s) in which fumigation will occur, their setting, proximity to other structures & their uses.</p> <p>Indoor use, non-persistence and non-mobility in soil, and negligible potential to contaminate surface waters (see "factor e," analysis, above) mean that geography, hydrology and soils have negligible bearing on safety, efficacy or appropriateness.</p> <p>Climate is relevant only in that extremely dry air can retard formation of phosphine gas from phosphine tablets, requiring appropriate adjustments to fumigation protocols. This is/is not anticipated to be an issue in XXX, where typical indoor temperatures will</p>

	range between X°C & Y°C and humidity between X and Y%.
(i) The availability and effectiveness of other pesticides or nonchemical control methods	<p>The fumigation PEA assesses the effectiveness and availability of non-chemical control methods, including weekly inspection for signs of rodents, weeding the perimeter around the warehouse, cleaning up spills and trash, ensuring that the warehouse doors, roofs, walls etc. are in good condition (Refer to Annex T-6 on IPM PRACTICES. As noted, the Safer Use Action Plan requires good housekeeping IPM measures such as daily sanitation of the warehouse and weekly clearing of warehouse surroundings of weeds; daily inspections for pests and strictly adhering to the first in first out (FIFO) rule to minimize the storage time of the commodities in the warehouse.</p> <p>The complementary contact pesticide [insert name] will be used to kill insects escaping fumigation and prevent re-infestation of the commodity. As documented by the PEA, such complementary use of contact pesticide(s) in and around warehouses is usually an integral part of the fumigation process.</p>
(j) The requesting country's ability to regulate or control the distribution, storage, use and disposal of the requested pesticide	<p>Partner country registration status is documented under Factor A, above.</p> <p>Note whether phosphine fumigation requires a license in your partner country, and the requirements for obtaining such a license. Note whether such licensing is meaningfully enforced.</p>
(k) The provisions made for training of users and applicators	<p>Regardless of partner country licensing, describe the training standard of fumigator service provider personnel.</p>
(l) The provisions made for monitoring the use and effectiveness of the pesticide	<p>The SUAP requires a Fumigation Management Plan that serves as detailed log of each fumigation episode. The FMP requires efficacy monitoring of phosphine gas concentrations to better assure that required concentrations are attained for the required period. This is critical to the efficacy of the individual fumigation and to preventing emergence of resistance. Monitoring of commodities for infestation is a routine element of program management; quick re-infestations are the primary indicator that fumigation is ineffective.</p>

FACTOR ANALYSIS FOR [INSERT NAME OF CONTACT PESTICIDE]

ANALYSIS FACTOR	ANALYSIS
(a) USEPA registration status of the proposed pesticide.	<p>Provide EPA registration status. Note that the pesticide must be registered for the same or similar uses by US EPA.</p>
Partner country registration status	<p>Provide analogous partner country registration information and any restrictions established by this registration. Note that the pesticide must be registered in the partner country AND by US EPA.</p>
(b) Basis for selection of the pesticide	<p>Availability, cost, efficacy, and relatively low toxicity to humans and non-target organisms should be key selection factors.</p>
(c) Extent to which	<p>The Safer Use Action Plan (SUAP) requires compliance with Fumigation PEA Annex T-6</p>

<p>the proposed pesticide use is, or could be, part of an IPM program</p>	<p>on IPM PRACTICES. This checklist contains good-housekeeping based Integrated Pest Management (IPM) practices that are essential complements to fumigation, including daily sanitation of the warehouse; clearing warehouse surroundings of weeds on a weekly basis; daily inspections for pests; and strictly adhering to the first in first out (FIFO) rule to minimize the storage time of the commodities in the warehouse.</p> <p>(List any additional IPM food commodity protection practices to which the program is committing.)</p>
<p>(d) Proposed method or methods of application, including the availability of application and safety equipment</p>	
<p>(e) Any acute and long-term toxicological hazards, either human or environmental, associated with the proposed use, and measures available to minimize such hazards.</p>	
<p>(f) Effectiveness of the requested pesticide for the proposed use.</p>	<p>Describe any resistance reported or known to you.</p>
<p>(g) Compatibility of the proposed pesticide use with target and non-target ecosystems.</p>	
<p>(h) The conditions under which the pesticide is to be used, including climate, flora, fauna, geography, hydrology, and soils</p>	<p>This pesticide will be used solely for spraying the interior and immediate perimeter of empty warehouses. The settings for these warehouses are described under the factor analysis for aluminum phosphide, above.</p> <p>Follow with additional relevant information.</p>
<p>(i) The availability and effectiveness of other pesticides or nonchemical control methods</p>	<p>The fumigation PEA assesses the effectiveness and availability of non-chemical control methods. As noted, the Safer Use Action Plan requires good housekeeping IPM measures such as daily sanitation of the warehouse and weekly clearing of warehouse surroundings of weeds; daily inspections for pests and strictly adhering to the first in first out (FIFO) rule to minimize the storage time of the commodities in the warehouse.</p> <p>The complementary contact pesticide [insert name] will be used to kill insects escaping fumigation and prevent re-infestation of the commodity. As documented by the PEA,</p>

	such complementary use of contact pesticide in and around warehouses is usually an integral part of the fumigation process.
(j) The requesting country's ability to regulate or control the distribution, storage, use and disposal of the requested pesticide	Partner country registration status is documented under Factor A, above. XXX does/does not have
(k) The provisions made for training of users and applicators	
(l) The provisions made for monitoring the use and effectiveness of the pesticide	

6. FINDINGS

In consequence of the analysis above, and the referenced Fumigation PEA, warehouse food commodity phosphine fumigation for **program name** food commodities and use of the complementary contact pesticides **[insert name(s)]** is [are] recommended for approval subject to full compliance with and implementation of the Safer Use Action Plan (SUAP) that constitutes the following section. The SUAP imposes on **program name** phosphine fumigation and complementary contact pesticide use the mitigation measures established by the Fumigation PEA.

In summary, these conditions are:

- Implementation of good-housekeeping IPM Measures that are essential complements to fumigation per [Fumigation Annex T-5](#)** “PHOSPHINE FUMIGATION SERVICES CONTRACT”.
- Implementation of a Fumigation Management Plan** for each fumigation event substantively conforming to the plan provided as [Annex T-3](#) “FUMIGATION MANAGEMENT PLAN (FMP) FOR PHOSPHINE FUMIGATION OF FOOD COMMODITIES IN SHEETED STACKS” to the Fumigation PEA.⁵
- Complementary Use of Contact Pesticides** will (1) be limited to the pesticide(s) authorized by this PERSUAP and substantively conform to contact pesticide best practices as set out in Fumigation PEA Annex T-6 on IPM PRACTICES.⁶
- Storage and Transport of Aluminum Phosphide and Contact Pesticides, if under program control**, will substantively conform to contact pesticide best practices as set out in Fumigation PEA [Annex T-6](#) on PM PRACTICES, EXCEPT for changes specified below and/or subsequently approved by the USAID Bureau for Democracy, Conflict and Humanitarian Assistance (DCHA) Bureau Environmental Officer (BEO).
- Food and feed commodities that have been fumigated with phosphine must be held and aerated for 48 hours prior to distribution.
- Monitoring and Corrective Actions.** Program will actively monitor compliance with above-listed conditions and undertake corrective actions as needed.

⁵ EXCEPT as noted in the SUAP

⁶ Ibid.

Formally, upon approval of this PERSUAP, the **program name** IEE is amended so that phosphine fumigation activities receive a 22 CFR 216 **negative determination** subject to the **condition** of compliance with the SUAP provided below.

7. SAFER USE ACTION PLAN (SUAP)

The SUAP is provided as a mandatory **“safer use action plan and compliance tracker” form**. This form both enumerates safer use requirements and sets out how program name will implement these requirements. Additionally, it serves as a compliance tracking and reporting tool, and will be submitted annually with regular reporting requirements.

Note: with respect to fumigation, the Safer Use Action Plan form satisfies the requirement for an environmental mitigation and monitoring plan (EMMP). The program EMMP should simply incorporate the SUAP by reference.

[INSERT USAID PROGRAM NAME]
FUMIGATION SAFER USE ACTION PLAN

Completion of this form is an integral part of the PERSUAP and must be submitted annually with regular reporting requirements.

PROGRAM & CONTACT INFORMATION		DATE OF ANNUAL REPORTING SUBMISSION:	
Awardee		Annual Update #1	
Program Name		Annual Update #2	
Fumigation Compliance Lead	<i>Name and title</i>	Annual Update #3	
Contact Information	<i>Email & telephone</i>	Annual Update #4	

FUMIGATION LOG (record all fumigation events since the last annual update)						
Dates	Location (Town or City)	Warehouse Type			Commodity & Quantity Fumigated	Key Exceptions/Incidents per FMP log.
		P*	S*	T*		

P=Primary, S=Secondary, T=Tertiary

REQUIRED COMPLIANCE MEASURES	STATUS OF COMPLIANCE ACTIONS (Place an X where applicable)
1. Good Housekeeping IPM Measures are implemented.	<input type="checkbox"/> Yes <input type="checkbox"/> No If “No”, please explain why, and detail when compliance is expected to take place:
2. A Fumigation Management Plan is implemented, with the required gas monitoring equipment, PPE and gas impermeable tarps for fumigation.	<input type="checkbox"/> Yes <input type="checkbox"/> No If “No”, please explain why, and detail when compliance is expected to take place:
3. The Use of Contact Pesticides is limited to pesticides authorized in this PERSUAP, and proper application, safety measures and PPE requirements are equally followed.	<input type="checkbox"/> Yes <input type="checkbox"/> No If “No”, please explain why, and detail when compliance is expected to take place:
4. Best practices in the storage and transport of Aluminum Phosphide and contact Pesticides are carried out.	<input type="checkbox"/> Yes <input type="checkbox"/> No If “No”, please explain why, and detail when compliance is expected to take place:
5. The third-party Fumigation Service Provider, if used, is in compliance with specified safer use practices	<input type="checkbox"/> Yes <input type="checkbox"/> No If “No”, please explain why, and detail when

	compliance is expected to take place:
6. Compliance monitoring and implementation of corrective actions:	<input type="checkbox"/> Yes <input type="checkbox"/> No If “No”, please explain why, and detail when compliance is expected to take place:

REQUESTED EXCEPTIONS AND CHANGES TO SPECIFIED MANAGEMENT PRACTICES

Enter here specific requested exceptions or changes to fumigation practices as described in the Fumigation Management Plan ([Fumigation PEA Annex T-3](#)) or storage, transport, and contact pesticide practices per [Annex T-6](#) on IPM PRACTICES. Reference by number & provide justification in each case. Alternately, a strike-through edit of the FMP may be submitted.

(insert extra rows if needed)

ANNEX T-3

TEMPLATE: FUMIGATION MANAGEMENT PLAN (FMP) FOR PHOSPHINE FUMIGATION OF FOOD COMMODITIES IN SHEETED STACKS

About FMPs. Fumigation Management Plans (FMPs) are widely recognized fumigation good practice, and are mandatory in the US. They are written documents that provide specific logistical, performance and contact information to better assure that fumigation follows systemic planning and execution for efficacy and safety.

FMP Requirements for USAID Partners. As described in Annex T-1, fumigation compliance requires USAID partners to complete a Fumigation Management Plan (FMP) for EACH fumigation event, and to keep these FMPs on file for 2 years. Compliance further requires that the plan and the fumigation event itself substantively confirm with the FMP template that follows. **In areas where Partners make substantial changes to the FMP template provided herein, they must submit the proposed changes to USAID for approval.**

Modifying this template. USAID partners must review this FMP template for compliance with local requirements and adjust accordingly. Other adjustments to local circumstances and capabilities are possible. *However*, any substantive changes must be requested in the Food Assistance Program's PERSUAP (the template for which is provided as Annex T-2 to this PEA) or subsequently in writing to the Food Assistance Program's AOR, who will forward for clearance to the DCHA Bureau Environmental Officer.

Purposes of this FMP template. This FMP template is NOT:

- A substitute for training in phosphine fumigation.
- A how-to manual for phosphine fumigation.
- Applicable without significant modifications to the fumigation of whole structures, containers, or vehicles.

This FMP template IS intended to very substantially reduce the effort required by USAID partners to develop a compliant FMP, and to conduct compliant (and therefore safer and more effective) fumigation of food commodities in sheeted stacks.

More specifically, this FMP template is a succinct summary of acceptable technical practice for phosphine fumigation of USAID-funded Food Commodities in sheeted stacks in a form that: (1) guides a trained fumigator to produce safe and efficacious results, (2) allows a USAID partner to better oversee their fumigation services provider; and (3) supports fumigation compliance reporting required by Food Aid Program PERSUAPs.

This template FMP embodies the acceptable technical practices for fumigation set out in annex T-7.

Key sources:

van Someran Graver, J. E. 2004. *Guide to Fumigation Under Gas-Proof Sheets*. Food and Agriculture Organization of the United Nations. Produced by the Australian Centre for International Agricultural Research, Canberra, Australia. Available at

http://www.fao.org/inpho_archive/content/documents/vlibrary/ad416e/FAOHomeIndex.htm (on-line e-book; includes accompanying videos) and

<http://http://aciarc.gov.au/files/node/543/FAO%20full%20text.pdf> (print-ready PDF).

“Standard Operating Procedure for Contractors Undertaking Phosphine Fumigation and Insecticide Spraying in WFP Stores” (Nov 2003 revision). World Food Program. Available at:
http://documents.wfp.org/stellent/groups/public/documents/manual_guide_proced/wfp254885.pdf.

“North Dakota Fumigation Management Plan Intermediate to Large Operations” North Dakota State University Department of Agriculture. Available at
<http://www.ag.ndsu.nodak.edu/aginfo/pesticide/pdf/fum/FMP%20int-lg.pdf>

Proper Disposal of Animal Carcasses in Michigan: An Industry Guide to the Bodies of Dead Animals Act. Michigan Department of Agriculture, Lansing, Michigan. Available at
http://www.michigan.gov/documents/MDA_BODA_80099_7.pdf.

Rodent Control: How to Use Rodent Traps and Bait Stations. Public Health Seattle & King County. Environmental Health Services, Seattle, Washington. Available at :
www.kingcounty.gov/healthservices/health/ehs/~/.RatTraps.ashx.

Dead Animal Disposal. Indiana State Board of Animal Health. Available at
<http://www.in.gov/boah/2369.htm>.



USAID Food Assistance Program Name:

PHOSPHINE FUMIGATION MANAGEMENT PLAN (FMP) (SHEETED STACKS ONLY)

**THIS FMP TEMPLATE PROVIDES A STEP BY STEP PROCESS TO
ENSURE SAFE AND EFFECTIVE FUMIGATION AND TRAIN
FUMIGATION PERSONNEL**

CONTENTS

COMMODITY AND OWNERSHIP.....	2
EMERGENCY PLANNING AND SAFETY	3
EQUIPMENT AND SUPPLIES.....	5
APPLICATION AND MONITORING.....	7
DISPOSAL AND CLEANUP	11
ANNEXED LOGS AND DOCUMENTATION	13

COMMODITY AND OWNERSHIP

PLANNED FUMIGATION DATES:

A. OVERALL PROGRAM & CONTACT INFORMATION

Lead Awardee	
Program Name	
Fumigation Compliance Lead	
Compliance Lead Contact Information	

ATTENTION:
To ensure full safety and efficacy, completion of this FMP is mandatory for each fumigation event.*

***Some information may remain the same across fumigation events.**

B. FACILITY INFORMATION

Name of Facility	
Location	
Responsible Manager (Name, Organization & Title)	
Contact Information	

C. FUMIGATOR INFORMATION

Lead Fumigator	
Organization	
Contact Information	
Certification # & Expiry Date (if any)	

D. COMMODITY TO BE FUMIGATED

Commodity(ies) & Amount in tons (est) (e.g. maize 200mt)	
Owner of	

E. FUMIGANT PRODUCT INFO & DOSAGE

E1. Fumigant (product name/description)	
E2. Ambient Temp (Expected indoor temp range)	
E3. Quantity Req'd	

D. COMMODITY TO BE FUMIGATED

commodity	
How commodity is packaged	
# of stacks & size (e.g., 4 stacks 3m X 2m X 2m)	
Last fumigation	Enter date if known. Otherwise, enter "unknown"
Condition	Moldy? Visibly infested?
Moisture %	
Purpose of Fumigation	

E. FUMIGANT PRODUCT INFO & DOSAGE

E4. Required time @ concentration* (e.g. 7 days @ 200ppm)	
E5. Planned downtime* (Days + hours, includes aeration.)	

***REQUIRED:**
DOCUMENT CALCULATIONS E3, E4 & E5 IN ANNEX #A. NOTE THAT EFFECTIVE PHOSPHINE FUMIGATION TYPICALLY REQUIRES 7-10 DAYS. .

EMERGENCY PLANNING AND SAFETY**F. CONTACT INFORMATION: MEDICAL FACILITY, EMERGENCY RESPONSE AUTHORITIES**

	LOCATION	TELEPHONE
Police		
Fire Service		
Clinic/Hospital		
Other Local Authority (specify Port Authority, District Council, Chieftaincy, etc.)		
Pesticide Regulatory Authority		
Chief of Party (or commodity point of contact)		

GI. ADVANCE NOTIFICATION PLAN FOR ABUTTERS

Specify the procedures for notifying those living and working within 100m of the facility. The fumigation team needs to alert relevant entities, particularly households, about fumigation activities.

G2. ADVANCE NOTIFICATION PLAN FOR LOCAL AUTHORITIES

Specify the procedure for notifying local authorities, as required or agreed with these authorities.

H. EMERGENCY RESPONSE PLAN

Describe the procedure to be followed if phosphine concentrations exceed (1) 0.3ppm (or local TLV, if more stringent), or (2) 1 ppm (or local STEL, if more stringent) (TLV= threshold limit value; STEL = short term exposure limit. See PEA Annex T-9).

I. FUMIGATION PLAN & EXCLUSION ZONE

REQUIRED ACTION:	Y	N	CONFIRMING INITIALS
11. Obtain plot or make scale sketch map of facility and surroundings. (note grid paper is provided as final page of this template)			
12. Mark locations of stacks to be fumigated.			
13. On plot, mark exclusion zone that maintains at least a 6M perimeter from stacks to be fumigated, and which INCLUDES buildings or rooms with walls common to the room in which the stack is being fumigated. An exception must be requested if the exclusion zone cannot be maintained.			
14. Determine if a watchman or watchmen will be required to maintain the			

exclusion zone. If yes, inform the facility manager immediately.			
15. On plot, mark shut-off points for electricity, water, gas, if any.			
16. On plot mark doors/gates to be secured to enforce exclusion zone and locations of warning signs to be posted.			
17. On plot, mark locations of hazard monitoring (at least 3 locations just outside exclusion zone, where gas is mostly likely to accumulate).			
18. On plot, mark locations of phosphine trays and monitoring lines.			
19. Attach plot to this Fumigation Management Plan as Annex #F			

J. COMMUNICATION AND TRAINING

REQUIRED ACTIONS	Y	N	CONFIRMING INITIALS
J1. Fumigation team reviews product label , MSDS, and applicator/product manual. Lead applicator provides detailed verbal briefing if required.			
J2. Lead applicator briefs the team regarding the symptoms of phosphine poisoning and first aid. (See Fumigation PEA Annex T-10)			
J3. Lead applicator briefs the team regarding the planned fumigation process with reference to the site plot (I10) WITH FACILITY MANAGER PRESENT			
J4. Lead applicator briefs the team & facility manager on EMERGENCY RESPONSE PLAN (H1) & roles and responsibilities for implementing the plan are agreed.			
J5. All employees engaged in fumigation instructed on the use, impact, and mitigation measures of phosphine fumigation.			

EQUIPMENT AND SUPPLIES

K. NUMBER OF SHEETS, SAND SNAKES AND TRAYS REQUIRED

REQUIRED ACTION:	QUANTITY REQUIRED
K1. Determine number of fumigation sheets required (note that joining sheets requires a <u>1(one) meter</u> overlap, tightly rolled & then clipped or weighted. If clips are used, they must be applied every 20cm.) <i>(Indicate number & size of sheets, standard 18meterX12meter sheets preferred)</i>	

K2. Determine length of sand snakes required (double rows must be used) (<i>in meters</i>)	
K3. Determine number of phosphine tablet trays required	

L. CONDITION, QUANTITY & ADEQUACY OF EQUIPMENT & SUPPLIES

FUMIGATION MAY NOT PROCEED UNLESS ALL ANSWERS ARE “YES”

CONFIRM THAT:	Y	N	CONFIRMING INITIALS
L1. Required quantity of sheets (K1) meeting specifications (M1) are available			
L2. Required length of sand snakes (K2) are available			
L3. Required number of tablet trays (K3) are available			
L4. Respiratory equipment and protective gear meeting specifications (M2) are available FOR THE FULL TEAM and all personnel can achieve a complete face seal. No one enters the fumigation area without protective gear.			
L5. (1) <u>Dry, clean cotton gloves</u> in good condition; (2) rubber boots; (3) liquid-tight coveralls are available FOR THE FULL TEAM			
L6. Detection (monitoring) equipment meeting specifications (M3) is available to monitor HAZARD			
L7. Detection (monitoring) equipment meeting specifications (M3) is available to monitor EFFICACY			
L8. Warning signs (placards) IN APPROPRIATE LANGUAGES and WITH APPROPRIATE PICTOGRAMS and compliant with host country regulations (if any) are available in quantity required by plot (I6)			
L9. Required quantity of fumigant (E3) is available			

M. SPECIFICATIONS FOR SHEETS, RESPIRATORY & DETECTION EQUIPMENT

M1. FUMIGATION SHEETS	M2. RESPIRATORY PROTECTION
<p>Sheets must be:</p> <ul style="list-style-type: none"> resistant to ultraviolet light tear-resistant along BOTH length and width of material impermeable to phosphine (gas loss must be less than 1 mg/day/m²) in good condition with ALL holes and 	<p>Properly maintained canister-type full facemask respirator. The canister must (1) be rated to protect against phosphine, (2) not expired, (3) not damaged, and (4) canisters previously used must not be opened more than 6 months ago & not have exceeded their rated time-in-use.</p> <p>OR</p> <p>Properly maintained self-contained breathing apparatus.(SCBA)</p> <p>Other varieties of respiratory protection may be acceptable, see</p>

<p>tears mended with material-specific adhesive and patch.</p> <ul style="list-style-type: none"> light enough to carry (200-250g/m²) a full standard-size (18mX12m) sheet <p>250-micron (0.25mm) thickness PVC sheet, PVC on a nylon or terylene scrim, or multi-layer thin-film laminates are all acceptable.</p> <p>Thin coatings on widely woven materials and annealed polypropylene sheets NOT acceptable.</p>	<p>PEA Annex T-9.NOTE. <u>Canister/cartridge type respirators are NOT adequate to enter a fumigation enclosure (e.g. go into a sheeted container)</u></p> <p>M3. MONITORING EQUIPMENT</p> <p>All equipment must be properly calibrated and maintained. Detector tubes, if used, must NOT be expired. Efficacy monitoring equipment must be able to read in the 200-500ppm + range. Hazard monitoring equipment must be able to accurately read in over the 0.3-3ppm + range.</p> <p>See PEA Annex T-9 for more information</p>
--	--

N. RESPIRATORY AND DETECTION EQUIPMENT			
Required Action: Complete log of all Respiratory and Detection Equipment.			
DESCRIPTION <i>e.g., Canister Respirator</i>	MANUF & MODEL #	MANUF DATE (IF KNOWN)	SERIAL NUMBER

*Note: advance notice of 24 or more hours may be required by country laws or regulations.

APPLICATION AND MONITORING

O. SUITABILITY OF FACILITY, STACKS AND TEAM FOR FUMIGATION			
BY FOLLOWING THESE STEPS, MANADATORY FUMIGATION WILL BE SAFE AND EFFECTIVE. FUMIGATION MAY NOT PROCEED UNLESS ALL CRITERIA ARE MET.			
MANDATORY STEPS. CONFIRM THAT:	CRITERION IS. . .		CONFIRMING INITIALS
	MET	NOT MET	
O1. Commodities being fumigated are not required for use before the end of the planned down time (E5) + 1 day			

O2. Expected temperature during the fumigation period will be 15°C or above.			
O3. Stacks are NOT built around pillars or against walls, and that there is sufficient clearance (1m) around each stack to effectively sheet and seal.			
O4. Surface issues: EITHER (1) the floor under <u>and for 1 (one) meter around stack</u> is crack-free concrete OR (2) the stack is placed on top of intact fumigation tarps. (If multiple tarps are used, they must be joined by tightly rolling a 1m overlap & weighting or clipping the join).			
O5. The marked exclusion zone (see I3) can be maintained for the duration of the fumigation (7-10 days or more). (Exclusion = no people EXCEPT for fumigation personnel with proper breathing equipment in this zone.)			
O6. A <u>trained</u> 2-person (or larger) team is available for application of fumigant and aeration and the team holds any required country licenses.			
O7. If watchmen are required to maintain the exclusion zone, they will be available over the entirety of the fumigation period, including aeration time.			
O8. The warehouse contains only the commodity to be fumigated.			

P. WARNING SIGNAGE AND SECURITY

REQUIRED ACTIONS	Y	N	CONFIRMING INITIALS
P1. <u>Notify Abutters</u> per Notification Plan (G1). In particular, ensure that nearby residents have been informed of activity,			
P2. <u>Notify Workers</u> and any others with customary access to the exclusion zone. Brief on emergency response plan (H1)			
P3. If applicable, execute Local Authorities Notification Plan (G2)*			
P4. Post <u>warning signage</u> at all points indicated by fumigation plot (I6)			
P5. Assure that doors are ready to be locked. (Locks and keys available)			
P6. Assure that watchmen are on-site, if required to maintain the exclusion zone.			

Q. PLACING SHEETING AND COVERING STACKS

REQUIRED ACTIONS IN EXACTLY THIS ORDER	Y	N	CONFIRMING INITIALS
Q1. <u>Position sheets.</u> Carry, do not drag the sheets into position			
Q2. <u>Cover stacks.</u> Unfold the sheets towards the stack. Place the sheet over the stack and position with 1 (one) meter of sheet lying on the ground. Unroll the sheet to cover the entire stack. If more than one sheet is used, join the sheets. Joins require a 1(one) m overlap, tightly rolled, and then clipped every 20cm or weighted.			

Q3. <u>Set sand snakes.</u> Smooth out any wrinkles and folds in sheets, and then place two rows of sand snakes on the sheets along the sides of the stack. Ensure that a good seal is achieved along the whole length and take special care at the corners.			
Q4. <u>Place monitoring lines.</u> Place two monitoring lines from the top and one from the bottom of each stack for efficacy monitoring. Cut small holes to insert tubes and seal holes in gas sheets with tape. Gas monitoring lines should extend outside of the exclusion area. Place duct tape over the free tube ends, except when measuring gas concentrations. Tubes MAY NOT be located near placement positions for phosphine tablets.			

R. APPLYING FUMIGANT

ATTENTION: PHOSPHINE GAS BEGINS FORMING AS SOON AS THE AIR-TIGHT PACKAGING OF PHOSPHIDE PELLETS/TABLETS IS OPENED. IT IS A DEADLY POISON. IT IS FLAMMABLE. CONTACT OF PHOSPHIDE WITH WATER WILL CAUSE FIRE OR EXPLOSION. SMELL IS NOT A RELIABLE INDICATOR OF DANGER.

REQUIRED ACTIONS IN EXACTLY THIS ORDER	Y	N	CONFIRMING INITIALS
R1. Watchmen go on duty (if required to maintain the exclusion zone) & remain OUTSIDE the zone until aeration is complete (W9)			
R2. Verify ONLY personnel involved in fumigation are in the exclusion zone			
R3. Turn off electric lights & any sources of sparks			
R4. Ensure that all fumigation personnel are wearing PPE, <u>including respirators</u> , as per L4 & L5			
R5. Lay out the trays for aluminum phosphide tablets/pellets around the stack. Remove the sand snakes that hold down the sheets next to the trays.			
R6. Distribute UNOPENED tablets/sachets next to the trays			
R7. Position tablets/pellets in a single layer on each tray. To avoid fire risk, do not pile tablets or pellets. Slide trays under the sheets and replace the sand snakes. To minimize worker exposure to gas being released, placement of trays should be completed within 15 minutes. Work from the back of the stack towards the exit doors. Pellets may NOT touch bagged commodities.			
R8. Assure all opened tablets/pellets are used			
R9. Leave the warehouse and lock ALL doors			

S. MONITOR GAS CONCENTRATIONS FOR EFFICACY AND HAZARD & LOG RESULTS

REQUIRED ACTIONS	Y	N	CONFIRMING INITIALS
S1. <u>Hazard Monitoring</u> . 1 hour, 2 hours, 4 hours & 24 hours after applying fumigant, and every 24 hours thereafter, monitor for hazard at all points designated on the fumigation plot (I7). Record results on attached log (#D).			
S2. <u>Hazard Monitoring Response</u> . If concentrations exceed 0.3ppm (or the local TLV,* if more stringent), assure that individuals move through the area only in passing. If concentrations exceed 1.0ppm (or the local STEL, if more stringent) evacuate the area. NOTE ANY SUCH ACTIONS IN EXCEPTIONS LOG (#C).			
S3. <u>Efficacy Monitoring</u> : Monitor EACH monitoring line 24 hours after fumigation application; every 24 hours thereafter. Monitor within stacks to confirm it was an effective fumigation application. Record results in attached logsheet (#E). NOTE ANY EXCEPTIONS IN LOG.			
S4. <u>Efficacy Monitoring Response</u> . If concentration does not reach or falls below 200ppm before additional fumigant may be added <u>IF SCBA apparatus are used</u> . NOTE ANY SUCH ACTIONS IN EXCEPTIONS LOG (#C).			

*threshold limit value. **short-term exposure limit see PEA Annex T-9.

T. CERTIFY FUMIGATION COMPLETE OR ABORTED

REQUIRED: CERTIFY WHICH OF THE FOLLOWING APPLIES.	✓	REQ'D TIME @ CONCENTRATION e.g. 200 ppm @ 7 days
T1. Efficacy monitoring results show that the required phosphine gas concentration was sustained over the required period in each stack		(Copy from E4)
T2. Efficacy monitoring results show that the required concentration was NOT sustained over the required period in one or more stacks.		

U. AERATE

REQUIRED ACTIONS IN EXACTLY THIS ORDER	Y	N	CONFIRMING INITIALS
U1. Fumigation team puts on respirators and other PPE per L4 and L5 before entering exclusion zone.			
U2. Open all doors and ventilators. Turn on fans, if any.			
U3. Remove sand snakes from the corners of up to 2 stacks so that sheet covering each can be lifted. (If the stacks are large relative to the			

size of the room, ONLY 1 stack can be opened at a time.)			
U4. Pull the free corner of each sheet up to the top of the stack with a rope. Team leaves exclusion zone immediately.			
U5. Allow gas to leave stack and warehouse for a half-day to 1 day			
U6. Repeat U1, U4 & U5 until remaining stacks are opened			
U7. Repeat U1. Then completely remove all sheets covering stacks.			
U8. Monitor inside warehouse and directly next to stack until phosphine gas concentration is less than 0.3 ppm (or local TLV value, if more stringent.)			
U9. ONLY AFTER CONCENTRATION IS LESS than 0.3 ppm (or local TLV value, if more stringent), lead fumigator informs facility manager that the area is safe to enter.			

DISPOSAL AND CLEANUP

V. ALUMINUM PHOSPHIDE RESIDUE REMOVAL & DISPOSAL

ATTENTION: Residues contain 3-5% unreacted materials and are hazardous to breathe and touch!

ATTENTION: NEVER DISPOSE OF UNUSED TABLETS/PELLETS WITH THESE METHODS. NEVER PLACE UNUSED PELLETS/TABLETS IN A DRUM WITH OR WITHOUT DETERGENT AS A FIRE OR EXPLOSION MAY OCCUR.

REQUIRED ACTIONS	Y	N	CONFIRMING INITIALS
V1. Personnel involved put on respirators and other PPE per L4 & L5.			
V2. Collect residue from trays in bucket or drum. Do <u>not</u> allow any residue to touch food commodity			
V3. Remove residue to a safe outdoor area			
V4. Remove warning signs & stand down watchmen			
V5. Standing upwind to avoid any evolved phosphine, mix residue slowly into soapy water, assuring the residue is fully reacted.			
V6. After any reaction is complete, dispose of mixture in a 0.5m deep disposal pit, at least 100m away from warehouse structures. Fill in hole.			

W. CLEAN-UP

ATTENTION: Dead animals should be considered a biohazard & must be disposed as soon as possible after aeration is complete

REQUIRED ACTIONS	Y	N	CONFIRMING INITIALS
W1. Crush empty phosphide tablet/pellets containers and dispose per host country requirements. If none, bury.			
W2. Inspect entire warehouse with flashlight, including under pallets and under-roof area for dead rodents and birds			

W3. Collect all dead animals wearing disposable gloves (if available). If not available, pick up with shovel or inside-out plastic bag.			
W4. Dispose of carcasses by (1) burying, wrapped in newspaper or plastic bag 0.6-1.2m deep and at least 60m from any shallow well or surface water; OR (2) burning, where it will not cause a public nuisance and in accordance with local laws; or (3) otherwise in accordance with local laws.			
W5. Wash hands thoroughly with soap.			

ANNEXED LOGS AND DOCUMENTATION

#A. DOCUMENTATION OF DOSAGE CALCULATION

Document the calculations/information used to determine the quantity of fumigant required and the “time @ concentration” efficacy threshold (e.g. 200 ppm @ 7 days)

General recommendation is 3 ALP tablets/metric ton but will vary with commodity, temperature & moisture content. 6 tablets/metric ton may be needed for highly sorptive commodities such as paddy rice, brown rice & pulses. Consult product label.

#B. FUMIGATION TIME LOG

#B1. Planned down time (days + hrs) (from H5)

#B2. Fumigant Applied (Date & Time)

#B3. Efficacy Reached (Day & Time that H4 is achieved)

#B4. Aeration Start (Date & Time)

#B5. All-Clear Given (see V9) (Date & Time)

#C. ISSUES, INCIDENTS AND EXCEPTIONS LOG

Log here any issues, incidents or exceptions that arise during the fumigation, including but not limited to phosphine concentrations > TLV outside the exclusion zone, violations of the exclusion zone, known or suspected problems with PPE discovered after the initial inspection, members of the fumigation team who become ill, addition of fumigant to reach or sustain required concentrations, etc.

#D. PHOSPHINE CONCENTRATION LOG: HAZARD MONITORING

Per S1, log phosphine gas concentrations taken at designated locations outside the exclusion area, in ppm.

LOCATION*	MONITORING TIME (TIME 0 = APPLICATION OF FUMIGANT)												
	1 hr	2 hr	4 hr	24 hr	1 day	2 days	3 days	4 days	5 days	6 days	7 days	8 days	9 days
A													
B													
C													

*As designated on plot map, Annex #F. Add locations as needed.

#E. PHOSPHINE CONCENTRATION LOG: EFFICACY MONITORING

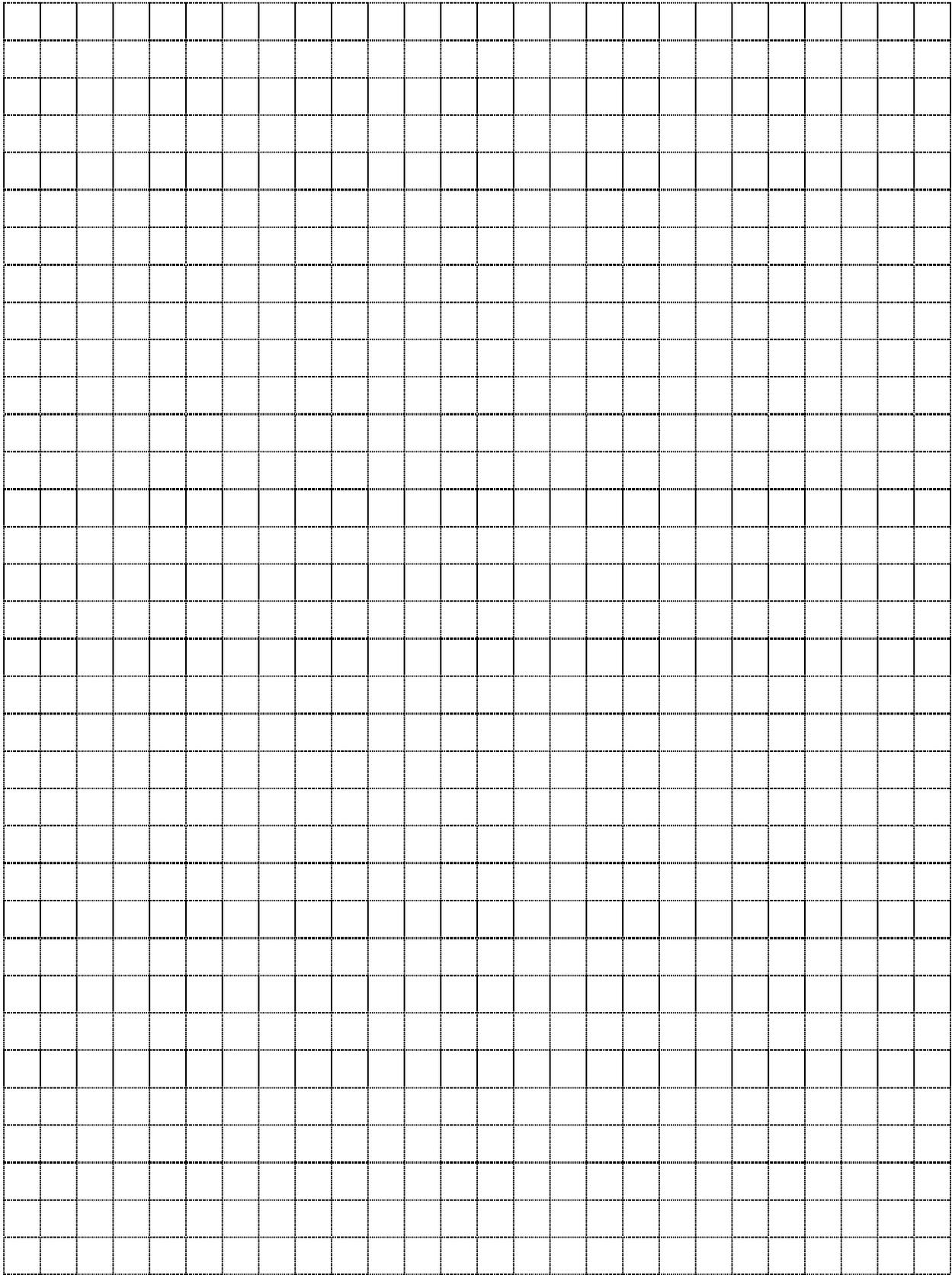
Per S3, log phosphine gas concentrations taken from monitoring lines, in ppm.

MONITORING LINE*	MONITORING TIME (TIME 0 = APPLICATION OF FUMIGANT)												
	24 hrs	2 days	3 days	4 days	5 days	6 days	7 days	8 days	9 days	10 days			
1													
2													
3													
4													

*As designated on plot map, Annex #F. Add lines as needed.

#F. SCALE MAP/PLOT OF FACILITY AND SURROUNDINGS, SHOWING EXCLUSION ZONE

(use this grid for a sketch map, if a more formal site map is not available. See section I for requirements)



ANNEX T-4 TEMPLATE: PHOSPHINE FUMIGATION SERVICES QUOTATION REQUEST

NOTE: Attach the Fumigation Management Plan (Annex T-3) as modified for your program to this quotation request.

Date

Dear Sir/Madam:

[Organization Name] requests a quotation for fumigation of [weight] of [type of] food commodities. Except for specifically agreed exceptions, the fumigation must be conducted in a manner conforming to the attached **Fumigation Management Plan (FMP)**.

If this RFQ is for recurring fumigation services (versus one time fumigation) state as much information as possible about the types and amounts of commodity to be fumigated.

_____ This will be a full warehouse fumigation

_____ This will be a fumigation of [number] stacks

The location(s) of performance is/are:

[Name(s) of warehouse, city/village, district/parish, etc.]

The expected dates of performance are [insert dates]. If this is for recurring fumigation, state how often fumigation should be conducted):

Other requirements:

(a) Please submit the names of the key fumigation workers and the types and dates of fumigation training that they have received in the last five years (If this is for recurring fumigation, request this information for the first fumigation; updates can be requested at a later date.)

(b) Please note that except as specifically negotiated, you must provide all equipment necessary to undertake the fumigation, including (1) an adequate number of high-quality fumigation sheets and sand snakes; (2) all necessary personal protective equipment including canister respirators or self-contained breathing apparatus; (3) phosphine gas monitoring equipment for both hazard and efficacy; (4) supplies for placarding and sealing the warehouse during the fumigation; and (5) all equipment otherwise required by the attached FMP. All equipment must meet specifications as established in the attached FMP.

(c) Please describe contact pesticides you intend to use, including the type of pesticide (product name, active ingredient), locations where you will apply, the application method, and the timeframe for spraying.

(d) Please advise on availability during the proposed timeframe, and the number of days required for the fumigation process, from tarping through aeration.

(e) No waste, including pesticide containers and fumigant packaging, shall be left on-site unless prior arrangements have been made with our office to safely dispose of the items.

Please quote your price and provide the above-requested information for the above fumigation services. Please also specifically state any requested exceptions to the specified fumigation plan, along with the reason for the requested exception.

ANNEX T-5 TEMPLATE: PHOSPHINE FUMIGATION SERVICES CONTRACT¹

The following is adapted from a World Vision contract for fumigation services.

NOTE: The Fumigation Management Plan (Annex T-3) as modified for your program serves as Annex 1 to this contract.

CONTRACT FOR FUMIGATION SERVICES

Between

[Name of PVO Organization, location of organization]

And

[Name of Fumigation Service Provider (FSP), location]

Both parties hereby enter into an agreement which states the following:

This agreement covers fumigation services to be rendered by [Name of Fumigation Service Provider/contractor] at the following location(s):

- Warehouse name, location, capacity
- Warehouse name, location, capacity

If during the period of this contract, the number of warehouse locations will be revised (increased or decreased), [PVO Organization] will notify contractor by letter. The floor area/capacity of each warehouse is an estimate, and the contractor is encouraged to visit each site, prior to fumigating, to investigate specific situations.

Expected Date(s) of Services: [insert dates]

[if this is a re-current contract, state expected frequency (i.e., every four to six weeks; or other timeframe, as applicable); if services may also be needed based on PVO's inspections (versus or in addition to a calendar-based schedule), state that additional services may be required, depending on warehouse inspections]

GENERAL PROVISIONS

- (1) [PVO Organization] will impose a penalty of [amount of penalty in local currency/day] if the contractor fails to perform the requested services in a timely manner, if due to the contractor's negligence (i.e., workers unavailable, fumigant unavailable, etc)
- (2) The contractor shall be responsible for re-fumigating at no cost to [PVO Organization] should [PVO Organization] deem the work was not done properly. Payment will be made only after satisfactory service has been rendered. This determination will be made by an authorized individual from [PVO Organization].
- (3) [PVO Organization] will/will not provide transport and accommodation of contractor's personnel from point of origin to warehouse(s) and return.
- (5) [Incorporate PVO's indemnification, dispute, payment clauses, termination clauses, and other legal/contractual requirements.]

¹ This template is a tool of the Fumigation PEA

FUMIGATION PROCESS REQUIREMENTS

- (1) Based on a written request from [PVO Organization], the contractor will fumigate stored commodities. [PVO Organization] will notify contractor of the desired date of services, the type of commodity, and the approximate amount of commodity to be fumigated.
- (2) Except as specifically agreed in a signed addendum to this agreement, the contractor must conduct the fumigation in a manner conforming to the attached **Fumigation Management Plan**.
- (3) The contractor shall abide by all local and national regulations regarding use of pesticides, including fumigants.
- (4) Except as specifically agreed in a signed addendum to this agreement, the contractor must provide all equipment necessary to undertake the fumigation, including (1) an adequate number of high-quality fumigation sheets and sand snakes; (2) all necessary personal protective equipment including canister respirators or self-contained breathing apparatus; (3) phosphine gas monitoring equipment for both hazard and efficacy; (4) supplies for placarding and sealing the warehouse during the fumigation; and (5) all equipment otherwise required by the attached FMP. All equipment must meet specifications as established in the attached FMP.
- (5) If a contact pesticide will be used, contractor must provide adequate PPE and ensure other safety procedures are in place so no environmental contamination results from use, including mixing, storing, applying, and disposing of contact pesticide.

ANNEX T-6

TEMPLATE: IPM PRACTICES & INSPECTION CHECKLIST FOR USAID-FUNDED COMMODITIES AND WAREHOUSES

This Inspection Checklist is a modified version of the checklist contained in the Food for Peace *Commodity Reference Guide*.² As modified, it implements key Integrated Pest Management (IPM) practices that are essential complements to fumigation.

STORAGE INSPECTION CHECKLIST

Date: _____

Inspected by: _____

Warehouse: _____

A. YARD AREA SURROUNDING WAREHOUSE:

On at least a weekly basis:

- ___ 1. Inspect the yard for signs of rodents (i.e., fecal pellets, tracks, burrows in the ground, holes, signs of feeding).
- ___ 2. Check to see that conditions do not attract insects (i.e., spilled commodities or other edible materials, empty containers, shrubs and trees, bird nests, weeds, trash, piled or damaged packing materials).
- ___ 3. Remove trash and unnecessary equipment and supplies regularly.
- ___ 4. Check the general security of the yard area surrounding the warehouse.
- ___ 5. Remove weeds from the perimeter of the warehouse.
- ___ 6. Check if water ponds at the perimeter of the warehouse and along access roads. If water ponds after a rain, grade the area to prevent water accumulation.

B. WAREHOUSE

For proper inspections, the warehouse should be well lit. Inspectors should conduct inspections using a flashlight (torch). Warehouse cleaning should be done daily; warehouse inspections should be carried out at least weekly.

- ___ 1. Check screens at the vents and other openings of the warehouse. If there are no screens, place screens at any openings into the warehouse. Use wire netting with mesh no larger than 6.35 mm or steel wool. Check for structural damage; use concrete to seal the opening.
- ___ 2. Check doors. Doors should be tightly fitting metal; make sure there are no gaps.
- ___ 3. Check for roof leaks.
- ___ 4. Check for holes in the walls.
- ___ 5. Ensure that the floor is sufficiently hard-packed to prevent burrowing by rodents.
- ___ 6. Check to see that the warehouse is well lit (as above, good lighting is required for proper inspections).
- ___ 7. Clean and service the anticoagulant and rodent bait stations regularly, and keep them filled with fresh bait (exterior use only). Bait stations should be tamper proof and secured to the ground with a concrete block and placed every 15-30 meters.
- ___ 8. Check rodent tracking powders (these should be placed on the exterior of the warehouse only).
- ___ 9. Check mousetraps (they should be emptied of dead mice **daily**). Only multiple-catch mouse traps, snap traps, and glue boards should be used in the interior of the warehouse. These should be placed every 15

² Food for Peace Commodities Reference Guide, Section III, updated January 2006.

http://transition.usaid.gov/our_work/humanitarian_assistance/ffp/crg/sec3.htm

meters along the floor wall junctions inside the warehouse and also underneath pallets if an infestation is suspected.

- ___ 10. Make sure that commodity stacks are positioned at least one meter from walls and other stacks to facilitate inspections.
- ___ 11. Ensure passageways are clean of spilled grain and debris.
- ___ 12. (For large and very large warehouses) Ensure three to four meters wide central aisles.
- ___ 13. Ensure stacks are at a reasonable height for ease of handling and to prevent damage to containers by crushing or falling from stacks.
- ___ 14. Ensure sides of stacks are flush.
- ___ 15. Ensure air spaces are provided between individual stacks.
- ___ 16. Ensure clean, unused packing material is neatly stacked.
- ___ 17. Ensure broken packing material is removed.
- ___ 18. Ensure the top of packing materials is covered to prevent spillage of food from damaged containers to ground or floor below.

C. DURING WORKING DAILY HOURS, CHECK THAT:

- ___ 1. Workers are lifting bags by the body instead of corners (to prevent tearing or weakening of the bag).
- ___ 2. Workers place bags on stacks, they do not throw bags.
- ___ 3 Workers clean empty bags and pallets thoroughly before they are reused and stack them neatly.
- ___ 4. When workers reconstitute/re-bag commodities from damaged container into good containers, they are adequately stitching the opening and weighing for correct quantity before stacking.
- ___ 5. Spilled commodity is not swept up into the reconstituted bag. This will help ensure that commodity will not be contaminated with pesticides that may have been sprayed in the empty warehouse.
- ___ 6. Warehouse doors and windows of are kept closed to discourage entry of insects, birds, and rodents.

D. COMMODITIES

On a daily basis check whether:

- ___ 1. Insects are present on damaged containers. Report presence of insects to warehouse supervisor.
- ___ 2. The exterior of stacked food containers is clean and free of mold, insects, rodents, and birds. Report presence of any of these to warehouse supervisor.
- ___ 4. Spoiled/infested food commodity is stored away from good commodity.
- ___ 5. Damaged commodities are removed promptly and rebagged. Use tape to seal small tears in paper bags.
- ___ 6. All floor sweepings are discarded and not re-bagged or otherwise used for human or animal consumption, as they may contain insecticide residue. If fumigating, discard all floor sweepings by placing them under fumigated tarps to kill any insects and discard after aeration.

At least on a weekly basis, inspect that:

- ___ 1. Individual commodities are stacked separately from one another.
- ___ 2. Food stacks are separated from non-food stocks.
- ___ 3. Records are current and adequate to document program of stock rotation (i.e., what is first in, is first out, or FIFO).
- ___ 4. Check to see that commodities are stacked on pallets to keep off the floor in both small and large warehouses.
- ___ 5. Pallets are not chipped nor are nails sticking out which could tear bags or injure workers.

REVIEW & APPROVAL

Name: _____ Signed: _____ Date: _____

ANNEX T-7

REFERENCE: FUMIGATION AND CONTACT PESTICIDE BEST MANAGEMENT PRACTICES

This annex contains best practice recommendations³ for the following:

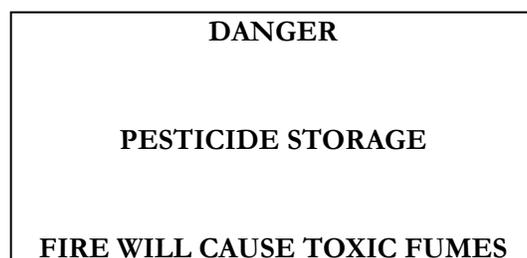
- Storage of pesticide containers (including fumigants)
- Disposal of pesticide containers (including fumigants)
- Transport of pesticides (including fumigants)
- Determining when to fumigate
- Soliciting and contracting for fumigation services
- Fumigation of stacks with aluminum phosphide
- Specifications and care of fumigation sheets/tarps
- Spraying empty warehouses & surroundings with contact pesticides

Annex T-3, the template Fumigation Management Plan, embodies these best practices for fumigation of stacks. Annex T-9 Respiratory and Monitoring Equipment and First Aid, and Annex T-6 Warehouse Checklist for additional best practices in commodity protection.

PROPER STORAGE OF PESTICIDE CONTAINERS (INCLUDING FUMIGANTS)

Proper storage of pesticides is essential to protect human health and well-being and to protect against environmental contamination. Proper storage will also extend the shelf life of pesticides.

1. A separate, isolated building should be dedicated for pesticide storage. The entrance to the storage area should be labeled/placarded as shown below in English and local language(s).



2. The storage building should be constructed of fire-resistant material and should contain a portable fire extinguisher and, if feasible, a sprinkler system.
3. Make sure the storage area is not leaky and does not get wet during rain. Vents should be closed in case of rain.

³ Sources are cited throughout.

4. The storage area should be well ventilated. High temperatures may cause some pesticide drumheads to bulge and leak. High temperatures may also cause emission of toxic fumes.
5. All pesticides must be stored in their original, labeled containers. Pesticides must never be stored in food, feed, or beverage containers.
6. Keep similar pesticides together, and separate them from other types of pesticides.
7. The lids of pesticide containers must be closed when they are not being used.
8. Place liquid containers on pallets to avoid corrosion of flooring.
9. Protect pesticide dusts from humidity to prevent caking.
10. Check containers periodically (at least monthly) for leaks or tears.
11. Make an inventory of all pesticides, including expiration dates, and keep records of use.
12. If multiple containers of a particular pesticide are stored, use the one closest to expiration first.
13. Do not store pesticide solutions in sprayers in the storehouse; use all of the mixed formulation.
14. In the case of phosphine, use all of the tablets/pellets in a container.
15. Do not store food, feed, water, or beverages in the pesticide storage area.
16. Do not store clothes, respirators, or other protective equipment in the pesticide storage area.
17. The storage area should have plenty of water and soap and an eye station in case of an accidental spill on hands or eyes.
18. Do not store pesticides for more than one year as they lose their activity.

PESTICIDE CONTAINER DISPOSAL (INCLUDING FUMIGANT PACKAGING)

Human/animal poisonings and environmental contamination may occur if pesticides and pesticide containers are not disposed of properly. In some countries, unused pesticide solutions can be taken to a designated collection place for incineration or disposal. In countries receiving food aid, such a facility may not exist. Therefore, all of the mixed chemical in a sprayer or a duster should be completely used. In the case of phosphine, all tablets/pellets in an opened container should be used for fumigation.

1. In the case of liquid pesticides, the empty container should be drained vertically for 30 seconds.
2. Triple rinse the container, each time using 1 liter of water for a sprayer of 3.84 L capacity. Allow 30 seconds for draining each time. The rinse water should be collected into a container and disposed of in an area away from any surface or ground water, following any local requirements.
3. Crush or break the container and dispose it in an approved manner, and do not reuse the container.
4. After all of the phosphine tablets/pellets are used, the empty container should be crushed and disposed as mentioned above.

Modified from: Bohmont, B. L. 1996. The Standard Pesticide User's Guide, Fourth Edition. Prentice Hall, New Jersey.

TRANSPORTING PESTICIDES INCLUDING FUMIGANTS

Transporting Aluminum Phosphide Packages

In the US, the US Department of Transportation (DOT) classifies aluminum phosphide as “Dangerous When Wet” material and it must be transported in accordance with DOT regulations. While these regulations do not apply to USAID programs in USAID host countries, they can provide a framework for implementation of safeguards when transporting aluminum phosphide packages. The US regulations are modified below so they can be applied to food assistance situations.

Packaging

No unsealed pouches may be transported. The completed outer packaging containing a combination of canisters and pouches should not exceed 21 kg.

Operational Controls

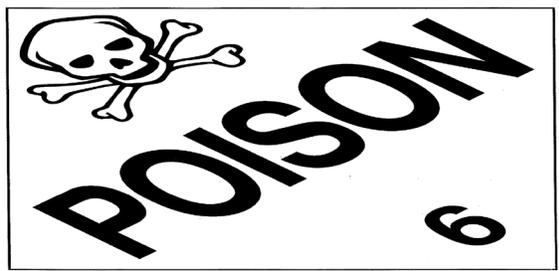
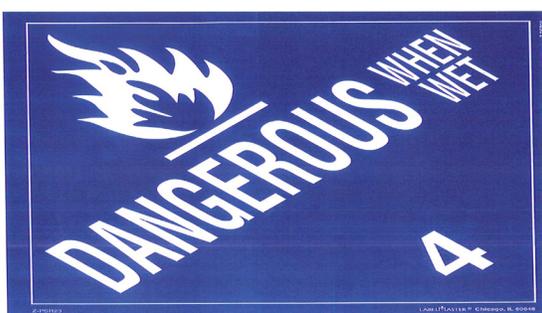
1. No more than 21 kg of aluminum phosphide may be transported by motor vehicles at any one time.
2. The complete packages must be stowed in metal boxes or compartments on the motor vehicle.
3. Only licensed pest control operators may transport the packages.
4. Each canister or foil pouch and the outer packaging must be labeled POISON and DANGEROUS WHEN WET (see below); vehicles need not display DANGEROUS WHEN WET PLACARDS. Miniature placards (2 cm by 2 cm) are can be used for inner canisters and pouches.

Special Provisions

1. Drivers must have been instructed as to necessary safeguards and proper procedures in the event of unusual delay, fire, or accident.
2. The person performing the transportation tasks must receive training on the requirements and conditions herein.

Reporting Requirements

Notification in writing, of any incident involving a package, shipment, or operation shall be made to the designated contracting authority within 24 hours.



DETERMINING WHEN TO FUMIGATE

Fumigation presents inherent risks to fumigators and those nearby. It should only be undertaken when there has been a specific determination of need. Appropriate decision rules for making this determination are provided in Annex T-12, “Deciding When to Fumigate.”

SOLICITING AND CONTRACTING FOR FUMIGATION SERVICES

Solicitations and Contract Documents must clearly establish that fumigation must comply with the practices for phosphine stack fumigation that follow immediately below, with any exceptions specifically negotiated and agreed. The training/qualifications of fumigation personnel and ability to comply with these practices must be key criteria in selecting fumigation service providers

The template Fumigation Services Quotation Request (Annex T-4) and the template Fumigation Services Contract (Annex T-5) provided in this PEA conform with these requirements.

FUMIGATION OF STACKS USING ALUMINUM PHOSPHIDE (ALP)

At temperatures of 25°C or above a minimum exposure time of 7 to 10 days is necessary to control phosphine-tolerant insect stages. The fumigation should be planned for a time period that will allow for this length of fumigation.

The following steps, adapted primarily from WFP's SOPs and the FAO's *Guide to Fumigation Under Gas-Proof Sheets*⁴, must be followed for safe, effective fumigation.

Overall: Fumigation Management Plan (FMP)

Planning for and implementation of the fumigation event must be documented in a Fumigation Management Plan (FMP). The fumigation plan should document: (1) responsible parties (facility manager and fumigators); (2) emergency contact information; (3) notification and emergency response plans; (4) commodities being fumigated, dosage and downtime calculations; (5) the spatial fumigation plan, (6) conformity with the key steps and decision criteria enumerated below; (7) gas concentration monitoring logs; and (8) any accidents, or exceptions to the procedures enumerated below.

(See below for explanations of these terms and concepts.)

Initial Preparations

1. Assemble emergency contact information, including: police and fire, if available. clinic/hospital; relevant local authorities (port authorities, district council, chieftancy, etc.); national pesticide regulatory authority; Food Assistance Program Chief of Party.
2. Develop an advance notification plan for (1) abutters (those living and working within 100m of the facility); and (2) for local authorities, as required or agreed
3. Develop an emergency response plan: what are the procedures to be followed if phosphine exceed the 0.3ppm (or TVL per host country regulations, if more stringent) in an area where bystanders/workers/local community members could be affected.
4. Characterize the commodity(ies) to be fumigated – amount (metric tons), how packaged, number of stacks and their size, condition, moisture content, and purpose of fumigation.

⁴ van Someran Graver, J. E. 2004. *Guide to Fumigation Under Gas-Proof Sheets*. Food and Agriculture Organization of the United Nations. Produced by the Australian Centre for International Agricultural Research, Canberra, Australia. Available at http://www.fao.org/inpho_archive/content/documents/vlibrary/ad416e/FAOHomeIndex.htm (on-line e-book; includes accompanying videos) and <http://http://aci-ar.gov.au/files/node/543/FAO%20full%20text.pdf> (print-ready PDF).

5. Determine the quantity of fumigant required and the planned total facility “downtime,” including aeration time for the fumigation. Document calculations. (General recommendation is dosage rate at 3 ALP tablets /metric ton but will vary with commodity and temperature). A dosage of 6 tables/metric ton may be needed for high sorptive commodities, such as paddy rice, brown rice, and pulses. Consult product label.)
6. Make a spatial fumigation plan and determine the exclusion zone: obtain or make a plot of the facility and its surroundings. Mark location of stacks to be fumigated and the exclusion zone from which all individuals except fumigators will be excluded for the duration of the fumigation. The exclusion zone must be at least a 6m perimeter from the stacks; more if required by local requirements.

Also mark on the plot shut-off points for electricity, water and gas (if any), door/gates to be secured to enforce the exclusion zone, and where warning signs should be posted.

Mark planned locations for hazard monitoring (at least 3, just outside the exclusion zone, where gas may accumulate) as well as planned location of phosphine trays and monitoring lines.
7. Determine whether a watchman or watchmen will be required to maintain the exclusion. If yes, inform facility manager immediately.

Determine Suitability of Facility, Stacks and Team for Fumigation.

DO NOT GO FORWARD WITH THE FUMIGATION IF ANY OF THE CRITERIA IN THIS SECTION ARE NOT MET.

Verify that all of the following criteria for fumigation are met:

1. The commodities being fumigated are not required before the end of the planned down time + 1 day.
2. Expected temperature during the fumigation period will be 15⁰C or above
3. Stacks are NOT built around pillars or against walls, and that there is sufficient clearance (1m) around each stack to effectively sheet and seal.
4. EITHER (1) the floor under and for 1m around stack is crack-free concrete OR (2) the stack is created on top of intact fumigation tarps. If multiple tarps are used, they must be joined by tightly rolling a 1m overlap & weighting or clipping the join
5. The marked exclusion zone can be maintained for the full planned facility downtime. (Again, no persons EXCEPT for fumigation personnel with proper breathing equipment will be allowed in this zone.)
6. A trained 2-person (or larger) team is available for application of fumigant and aeration and the team holds any required host country licenses.
7. If a watchman(men) is required to maintain the exclusion zone, they will be available over the entirety of the fumigation period, including aeration time.

Confirm Condition, Quantity & Adequacy of Equipment & Supplies

DO NOT PROCEED WITH FUMIGATION UNLESS ALL EQUIPMENT AND SUPPLIES LISTED BELOW ARE ON-HAND.

1. Determine the number of fumigation sheets required. (Note that joining sheets requires a 1m overlap, tightly rolled and then clipped or weighted. Confirm that adequate sheets meeting specifications per box on next page are available.
2. Calculate the number of sand snakes required (two rows should be used) to place around the stack to be fumigated. In the absence of sand snakes, use other bagged commodities. Confirm that adequate quantity is on hand.
3. Calculate the number of trays for ALP tablets/pellets required. Confirm that adequate quantity is on hand.
4. Confirm that respiratory equipment meeting specifications in Annex T-9 is available FOR THE FULL TEAM and all personnel can achieve a complete face seal. Maintain a log of this equipment.
5. Confirm that . Detection (Monitoring) Equipment is available to monitor both HAZARD and EFFICACY per specifications in Annex T-9. Maintain a log of this equipment.
6. Confirm that (1) dry, clean cotton gloves in good condition; (2) rubber boots; (3) liquid-tight coveralls are available FOR THE FULL TEAM
7. Confirm that warning signs (placards) IN APPROPRIATE LANGUAGES and WITH APPROPRIATE PICTOGRAMS and compliant with host country regulations (if any) are available in quantity required by the spatial fumigation plan.
8. Consider the need to spray contact pesticides prior to fumigation, such as spraying the store structure and stack surfaces (see below).
 - In accordance with PVO procedures, notify appropriate PVO staff, including warehouse managers, workers and other employees about the fumigation and its duration, including safety precautions to be followed; notify neighbors if they are within 100 meters of the fumigated warehouse; and have phone numbers of physicians, police, and fire department in case of an accident or emergency.

SPECIFICATIONS FOR FUMIGATION (GAS-PROOF) SHEETS OR TARPS AND PROPER CARE OF SHEETS

Specifications:

- Sheets must be resistant to ultraviolet light. They must be resistant to tearing along both length and width and impermeable to phosphine (gas loss should be less than 1 mg/day/m²).
- Sheets must be 250 microns thick (1 micron = 1/1000 of a mm), and light weight (200-250 g/m²).
- Standard 18 x 12 m sheets are strongly recommended.
- Sheets must be in good condition, with all holes and tears mended with material-specific adhesive and patch.

Fumigation sheets are generally made of unsupported polyvinyl chloride (PVC), woven polythene, PVC laminate, PVC on a nylon or terylene scrim, or multi-layered thin-film laminates.

Annealed polypropylene sheets and thinly coated and widely woven materials must not be used as fumigation sheets.

Care of Sheets:

- To prevent tears, sheets should not be pulled or dragged over rough ground or walked on. .
- Sheets should be stored in a place where they will not be damaged by rodents.
- Prior to each use, hang sheets on long supports and inspect against light for any holes. Seal with material-specific adhesive and patch.

Brief Fumigation Team & Facility Manager.

1. Fumigation team reviews product label, MSDS, and applicator/product manual. Lead applicator provides detailed verbal briefing if required (e.g. if one or more team members cannot read the product label.)
2. Lead fumigator briefs the team regarding the symptoms of phosphine poisoning and first aid. (See Fumigation PEA Annex T-10)
3. Lead fumigator briefs the team regarding the planned fumigation process with reference to the site plot WITH FACILITY MANAGER PRESENT. Roles and responsibilities of each person are understood and agreed.
4. Lead fumigator briefs the team & facility manager on EMERGENCY RESPONSE PLAN (F1) & roles and responsibilities for implementing the plan are agreed.

Notify and Post Warning Signage, Assure Watchmen on Standby

1. Notify Abutters per Notification Plan
2. Notify Workers and any others with customary access to the exclusion zone. Brief them on the emergency response plan
3. If applicable, execute Local Authorities Notification Plan
4. Post warning signage at all points indicated by fumigation plot
5. Assure that doors are ready to be locked. (Locks and keys available)
6. Assure that watchmen are on-site and ready to go on-duty, if required to maintain the exclusion zone.

Sheet the Stack

1. Unfold the sheets towards the stack. Always carry the sheet, never drag it over the ground.
2. Place the sheet over the stack and position with 1meter of sheet lying on the ground.
3. Unroll the sheet to cover the entire stack.
4. Take care when climbing on stacks or up ladders while covering the stacks to avoid falling over the edge.
5. Smooth out any wrinkles and folds in the sheets before placing sand snakes on them.
6. If more than one sheet is used, join the sheets. (Again, joins require a a 1m overlap, tightly rolled and then clipped or weighted.)
7. Place two rows of sand snakes on the sheets along the sides of the stack. Ensure that a good seal is achieved along the whole length and take special care at the corners.
8. Place two monitoring lines from the top and one from the bottom of each stack to determine if phosphine concentration of 200-300 ppm is maintained for the duration of exposure. Cut small holes to insert tubes and seal holes in gas sheets with tape.
9. Gas monitoring lines should be placed outside of treated area. Place duct tape over the free tube ends, except when measuring gas concentrations with electrochemical or tube type gas monitoring equipment.

Apply Fumigant.

ATTENTION: PHOSPHINE GAS BEGINS FORMING AS SOON AS THE AIR-TIGHT PACKAGING OF PHOSPHIDE PELLETS/TABLETS IS OPENED. IT IS A DEADLY POISON. IT IS FLAMMABLE. CONTACT OF PHOSPHIDE WITH WATER WILL CAUSE FIRE OR EXPLOSION. SMELL IS NOT A RELIABLE INDICATOR OF DANGER

1. Watchmen go on duty (if required to maintain the exclusion zone) & remain OUTSIDE the zone until aeration is complete (min 7-10 days).
2. Verify ONLY personnel involved in fumigation are in the exclusion zone
3. Turn off electric lights & any sources of sparks
4. Ensure that all fumigation personnel are wearing above-specified PPE, including respirators⁵
5. Lay out the trays for aluminum phosphide tablets/pellets around the stack. Remove the sand snakes that hold down the sheets next to the trays.
6. Distribute UNOPENED tablets/sachets next to the trays.
7. Position tablets/pellets in a single layer on each tray. To avoid fire risk, do not pile tablets or pellets. Slide trays under the sheets and replace the sand snakes. To minimize worker exposure to gas being released, placement of trays should be completed within 15 minutes. Work from the back of the stack towards the exit doors. Pellets may NOT touch bagged commodities.
8. Assure all opened tablets/pellets are used.
9. Leave the warehouse and lock ALL doors.

Monitor Gas Concentrations for Efficacy and Hazard & Log Results

1. Hazard Monitoring. 1 hour, 2 hours, 4 hours & 24 hours after applying fumigant, and every 24 hours thereafter, monitor for hazard at all points designated on the spatial fumigation plan. Record results in a log that is part of the fumigation management plan.
2. Hazard Monitoring Response.. If concentrations exceed 0.3ppm (or the local TLV,⁶ if more stringent), assure that individuals move through the area only in passing. If concentrations exceed 1.0ppm (or the local STEL,⁷ if more stringent) evacuate the area. NOTE ANY SUCH ACTIONS IN THE EXCEPTIONS/INCIDENTS LOG attached to the fumigation management plan.
3. Efficacy Monitoring: Monitor EACH monitoring line 24 hours after fumigation application; every 24 hours thereafter. Record results in a log that is part of the fumigation management plan.
4. Efficacy Monitoring Response. If concentration does not reach or falls below 200ppm before additional fumigant may be added ONLY IF SCBA apparatus are used. NOTE ANY SUCH

⁵ See PPE list in "Confirm Condition, Quantity & Adequacy of Equipment & Supplies"

⁶ Threshold Limit Value, see Annex T-9.

⁷ Short Term Exposure Limit; see Annex T-9.

ACTIONS IN THE EXCEPTIONS/INCIDENTS LOG attached to the fumigation management plan.

Certify Fumigation Complete or Aborted

The lead fumigator must formally communicate to the facility manager which of the following applies.

1. Efficacy Monitoring results show that the required phosphine gas concentration was sustained over the required period in each stack
2. Efficacy monitoring results show that the required concentration was NOT sustained over the required period in one or more stacks. These stacks must be specifically identified.

Aerate

1. Fumigation team puts on respirators and other PPE⁸ before entering exclusion zone.
2. Open all doors and ventilators. Turn on fans, if any.
3. Remove sand snakes from the corners of up to 2 stacks so that sheet covering each can be lifted. (If the stacks are large relative to the size of the room, ONLY 1 stack can be opened at a time.)
4. Pull the free corner of each sheet up to the top of the stack with a rope. Team leaves exclusion zone immediately.
5. Allow gas to leave stack and warehouse for a half-day to 1 day
6. Repeat steps 1, 4 & 5 until remaining stacks are opened
7. Repeat step 1. Then completely remove all sheets covering stacks.
8. Monitor inside warehouse and directly next to stack until phosphine gas concentration is less than 0.3 ppm (or local TLV value, if more stringent.)
9. ONLY AFTER CONCENTRATION IS LESS than 0.3 ppm (or local TLV value, if more stringent), lead fumigator informs facility manager that the area is safe to enter.

⁸ See PPE list in "Confirm Condition, Quantity & Adequacy of Equipment & Supplies"



Aluminum Phosphide Residue Removal & Disposal⁹

ATTENTION: RESIDUES CONTAIN 3-5% UNREACTED MATERIALS AND ARE HAZARDOUS TO BREATHE AND TOUCH!

ATTENTION: NEVER DISPOSE OF UNUSED TABLETS/PELLETS WITH THESE METHODS. NEVER PLACE UNUSED PELLETS/TABLETS IN A DRUM WITH OR WITHOUT DETERGENT AS A FIRE OR EXPLOSION MAY OCCUR.

1. Personnel involved put on respirators and other PPE¹⁰
2. Collect residue from trays in bucket or drum. Do not allow any residue to touch food commodity
3. Remove residue to a safe outdoor area
4. Remove warning signs & stand down watchmen
5. Standing upwind to avoid any evolved phosphine, mix residue slowly into soapy water, assuring the residue is fully reacted.
6. After any reaction is complete, dispose of mixture in an 0.5m deep disposal pit, at least 100m away from warehouse structures. Fill in hole.

⁹ from: van Someran Graver, J. E. 2004. Guide to Fumigation Under Gas-Proof Sheets. Food and Agriculture Organization of the United Nations. Produced by the Australian Centre for International Agricultural Research, Canberra, Australia.

¹⁰ See PPE list in "Confirm Condition, Quantity & Adequacy of Equipment & Supplies.

Clean-up¹¹

ATTENTION: DEAD ANIMALS SHOULD BE CONSIDERED A BIOHAZARD & MUST BE DISPOSED AS SOON AS POSSIBLE AFTER AERATION IS COMPLETE

Rodents and birds gain entry into food aid warehouses through structural gaps in the building. Entry is more likely in temporary tent-type structures that store food. Fumigation to kill stored-product insect pests will also kill rodents and birds. After fumigation, the warehouse must be inspected to locate all dead rodents and birds and they must be promptly disposed of (24 hours). The rate of decomposition is faster in tropical and sub-tropical climates than in colder climates. If not promptly disposed of, odor and disease transmission are concerns. In addition, secondary infestations of flesh flies, carrion beetles, blow flies, carpet beetles, and cockroaches could result. Dead animals must be disposed of within 24 hours after fumigation is complete to avoid these issues.

1. Crush empty phosphide tablet/pellets containers and dispose per host country requirements. If none, bury.
2. Inspect entire warehouse with flashlight, including under pallets and under-roof area for dead rodents and birds
3. Collect all dead animals wearing disposable gloves (if available). If not available, pick up with shovel or inside-out plastic bag.
4. Dispose of carcasses by (1) burying, wrapped in newspaper or plastic bag 0.6-1.2m deep and at least 60m from any shallow well or surface water; OR (2) burning, where it will not cause a public nuisance and in accordance with local laws; or (3) otherwise in accordance with local laws.
5. Wash hands thoroughly with soap.
- 7. Dispose of empty phosphine containers

OPTIONAL: SPRAYING WAREHOUSE STRUCTURES (EMPTY WAREHOUSE AND SURROUNDING AREAS)¹²

Consider spraying the empty warehouse (floor, walls, roofs, etc.) and surrounding areas with contact (residual) pesticide before receipt of food commodities to kill any live insects. The perimeter of the warehouse on the outside should be sprayed, as described below. The aim is to kill insects that might escape the fumigation.

¹¹ modified from:

Bohmont, B. L. 1996. The Standard Pesticide User's Guide, Fourth Edition. Prentice Hall, New Jersey.

Proper Disposal of Animal Carcasses in Michigan: An Industry Guide to the Bodies of Dead Animals Act. Michigan Department of Agriculture, Lansing, Michigan. Available at: http://www.michigan.gov/documents/MDA_BODA_80099_7.pdf.

Rodent Control: How to Use Rodent Traps and Bait Stations. Public Health Seattle & King County. Environmental Health Services, Seattle, Washington. Available at : www.kingcounty.gov/healthservices/health/ehs/~/_/.../RatTraps.ashx.

Dead Animal Disposal. Indiana State Board of Animal Health. Available at <http://www.in.gov/boah/2369.htm>.

¹² Modified from World Food Program Standard Operating Procedures.

As per Annex T-1, USAID partners must submit a PERSUAP to USAID that requests specific pesticides. That PERSUAP must specify practices at least as stringent as those below; see PERSUAP template in Annex T-2.

1. Clean empty warehouse of all food grains and debris. This will increase insecticide effectiveness.
2. Ensure spray equipment is well maintained and make repairs prior to spraying.
3. Give prior notice of the spraying to warehouse staff whose work is likely to be disrupted.
4. Calculate the area to be sprayed (usual recommended rate is two to five liters of water/100 square meters) and provide sufficient insecticide (recommended dosage rate 2% active ingredient in the solution or as recommended by the label). Ensure adequate water and sprayers are available, and that protective clothing and washing water and soap is available.
5. Protective clothing, including boots, long sleeve shirts, pants, disposable gloves, goggles, and coveralls should be worn by applicators. In some cases, cartridge type of masks should be worn to protect against inhaling spray droplets. Check label for respiratory protection needed.
6. Calibrate sprayer by adjusting volume of water needed to cover a known amount of floor area.
7. Provide clear instructions to applicators as to the parts of the warehouse to be treated and an estimate of the area to be covered with one knapsack sprayer of pesticide.
8. Give special instructions, for example, about applying heavier than normal dosages of spray to places where insects might be concentrated (i.e., cracks and crevices in walls and floors).
9. Notify applicators about hazards such as electrical equipment, dimly lit areas, and slippery floors.
- 10. Mix pesticides in a well-ventilated area using disposable gloves and goggles. If a pest management service provider is used for spraying, pesticides should be mixed off-site before arriving on warehouse grounds. For additional guidance in mixing and handling pesticides, see below.**
11. Spray empty warehouse (floor, walls, roofs, etc.) and surrounding areas before receipt of food commodities to kill any live insects. The perimeter of the warehouse on the outside should be sprayed. Do not spray near waterways; spray at least 50 meters away from the edge of a surface water body. An approved contact pesticide must be used.
12. Inspect immediately after spraying that all areas have been properly treated. Any surplus spray remaining in the sprayers should be applied to walls to use it up. Diluted water-based sprays should not be retained in the sprayer for longer than one day since the insecticide may deteriorate rapidly.
13. Empty the sprayers and wash thoroughly with clean water. Dismantle and clean nozzles. Drain and dry spray tanks, hoses, and lances. Triple rinse sprayers and collect rinse water and dispose safely and securely, preferably in an area designated for this waste, in an area where it will not affect non-target organisms. Empty insecticide containers should be disposed of safely by crushing them and placed in a safe, secure pit/landfill, and covered.
14. Applicators should wash hands thoroughly with soap and warm water. Clothes worn during application should be washed with soap and water. Do not reuse gloves. Goggles should be thoroughly washed in soap and water and dried.
15. As required by PVO procedures, report the area of a warehouse sprayed and the type and quantity of pesticides used.

ADDITIONAL INFORMATION ON PROPER HANDLING AND MIXING OF PESTICIDES

Spills and splashes can occur when mixing pesticides with water in sprayers. The following safety instructions should be observed during the mixing and loading of pesticides:

1. After selecting a pesticide for spraying the warehouse, follow label directions for using correct amount of the pesticide and do not exceed label rates.
2. Wear protective clothing and respirator as stated by the label, and have first aid equipment available.
3. Never work alone when handling highly hazardous pesticides.
4. Mix chemicals outside or in a well-ventilated area and not inside the warehouse.
5. Do not mix chemicals near surface water. Mixing should occur at least 50 meters away from surface water.
6. Always stand upwind when mixing or loading pesticides.
7. The measuring containers should be thoroughly cleaned after each use.
8. First add water to the spray tank, then add the pesticide and fill the spray tank to the desired level.
9. Clean up spilled pesticides immediately. If the pesticide is accidentally spilled on skin, immediately wash it off with soap and water. Notify supervisor to ensure that appropriate procedures are taken to avoid injury.
10. If the pesticide is spilled on clothing, change clothing as soon as possible and wash clothes before using them again.
11. Protective gloves should be washed before removing them.
12. Wear new gloves each time as the pesticide residues can be absorbed into the glove matrix. Discard gloves as above for pesticide containers.
13. Persons mixing, handling, or applying pesticides should never smoke, eat, or drink until after they have thoroughly washed their hands with soap and water.
14. Never use your mouth to siphon a pesticide from a container.

ANNEX T-8

REFERENCE: ALUMINUM PHOSPHIDE MSDS & PHOSPHINE FACTSHEET

This Annex provides (1) a sample Aluminum Phosphide Material Safety Data Sheet (MSDS), and (2) US EPA's Phosphine Factsheet.

Note that no endorsement of Degesch Products is implied. The Phostoxin applicator manual (expanded label) can be accessed from: <http://www.degeschamerica.com/docs/USA/Phostoxin%20Tablet-Pellet%20manual.pdf>



MATERIAL SAFETY DATA SHEET: ALUMINUM PHOSPHIDE

	<u>U.S. EPA Reg. No.</u>
PHOSTOXIN® TABLETS	72959-4
PHOSTOXIN® PELLETS	72959-5
PHOSTOXIN® TABLET PREPAC	72959-9
PHOSTOXIN® PREPAC ROPES	72959-8
DETIAPHOS® FUMEX BAGS, BELTS AND BLANKETS	72959-10
DETIAPHOS® TABLETS	72959-4
DETIAPHOS® PELLETS	72959-5

PROPER DOT SHIPPING NAME: UN1397 ALUMINUM PHOSPHIDE, 4.3 (6.1) PG-I DANGEROUS WHEN WET, POISON LABELS APPLY

SECTION I - PRODUCT INFORMATION

Manufacturer:

DEGESCH America, Inc.
153 Triangle Dr.
P. O. Box 116
Weyers Cave, VA 24486 USA

Telephone: (540) 234-9281 / 1-800-330-2525
Telefax: (540) 234-8225
Internet Address: www.degeschamerica.com
E-mail: degesch@degeschamerica.com

EMERGENCY TELEPHONE NOS.:

Emergency – Call PROSAR: 1-800-308-4856 for human or animal emergencies
Call Chemtrec: 1-800-424-9300 for all other chemical emergencies
Emergency and Information - DEGESCH America, Inc. (540) 234-9281 / 1-800-330-2525

Phostoxin and DetiaPhos are available as 0.6g pellets and 3.0g tablets. Tabletized Phostoxin is also available in gas permeable packages called Prepacs and Ropes. These products are packed in gas-tight containers. Detia® Fumex is available as 34g bags. Fumex is also packed as bag belts, each equivalent to 4 bags and bag blankets, equivalent to 100 bags.

Date of Revision: April 2011

SECTION II - HAZARDOUS INGREDIENTS INFORMATION

Identity:

Phostoxin, Fumex, DetiaPhos and Aluminum Phosphide (AIP) - react with water to produce phosphine (Hydrogen phosphide, PH₃) as shown in Equation 1. Phostoxin and DetiaPhos is formulated with 55% aluminum phosphide and also contains ammonium carbamate (AC) and inert ingredients. Ammonium carbamate releases ammonia and carbon dioxide as shown in Equation 2. Detia Fumex bags do not contain ammonium carbamate.



AIP CAS No. 20859-73-8
PH₃ CAS No. 7803-51-2
Al(OH)₃ CAS No. 21645-51-2

NH₂COONH₄ CAS No. 1111-78-0
NH₃ CAS No. 7664-41-7
CO₂ CAS No. 124-38-9

NFPA Chemical Hazard Ratings:

Flammability Hazard 4
Health Hazard 4
Reactivity Hazard 2
Special Hazard W

SARA Physical and Health Hazards:

Fire
Reactivity
Immediate (Acute)

Inhalation Exposure Limits:

Component	OSHA PEL	ACGIH TLV		NIOSH
	TWA (ppm)	TWA (ppm)	STEL (ppm)	IDLH (ppm)
Phosphine (Hydrogen Phosphide, PH ₃)	0.3	0.3	1.0	50
Ammonia	50	25	35	300
Carbon Dioxide	5,000	5,000	30,000	40,000

SECTION III - PHYSICAL CHARACTERISTICS

Boiling Point:

AIP >1000°C
PH₃ -87.7°C

Specific Gravity of Vapors (Air = 1):

AIP N/A
PH₃ 1.17

Vapor Pressure:

AIP 0mm Hg
PH₃ 40mm Hg @-129.4°C
AC 100mmHg @26.7°C

Solubility in Water:

AIP Insoluble, reacts
PH₃ 26cc in 100 ml water at 17°C
AC Very soluble, reacts

Appearance and Odor:

The Phostoxin, DetiaPhos and Fumex formulations, and aluminum phosphide have a greenish-gray color and the hydrogen phosphide (phosphine, PH₃) gas produced by these chemicals has an odor described as similar to garlic, carbide or decaying fish.

Specific Gravity:

AIP 2.85

Melting Point:

AIP >1000°C

PH₃ -133.5°C

SECTION IV - FIRE AND EXPLOSION HAZARD DATA**Flash Point:**

Aluminum phosphide, Phostoxin, DetiaPhos and Fumex are not themselves flammable. However, they react readily with water to produce phosphine (hydrogen phosphide, PH₃) gas which may ignite spontaneously in air at concentrations above its LEL of 1.8% v/v (18,000 ppm). UEL of phosphine (hydrogen phosphide, PH₃) is not known.

Extinguishing Media:

Suffocate flames with sand, carbon dioxide or dry extinguishing chemicals.

Special Fire Fighting Procedures:

Do not use water on metal phosphide fires.

Respiratory Protection:

Wear NIOSH/MSHA approved SCBA or equivalent respiratory protection.

Protective Clothing:

Wear gloves when handling Phostoxin, and DetiaPhos tablets, pellets or dust.

Unusual Fire and Explosion Hazards:

Phosphine (hydrogen phosphide, PH₃)-air mixtures at concentrations above the lower flammable limit of 1.8% v/v (18,000 ppm), Phosphine (hydrogen phosphide, PH₃) may ignite spontaneously. Ignition of high concentrations of phosphine (hydrogen phosphide, PH₃) can produce a very energetic reaction. Explosions can occur under these conditions and may cause severe personal injury. Never allow the buildup of phosphine (hydrogen phosphide, PH₃) to exceed explosive concentrations. Open containers of metal phosphides in open air only and never in a flammable atmosphere. Do not confine spent or partially spent dust from metal phosphide fumigants as the slow release of phosphine (hydrogen phosphide, PH₃) from these materials may result in the formation of an explosive atmosphere. Spontaneous ignition may occur if large quantities of aluminum phosphide or magnesium phosphide are piled in contact with liquid water. This is particularly true if quantities of these materials are placed in an environment which can provide partial confinement of the hydrogen phosphide gas liberated by hydrolysis.

Fires containing phosphine (hydrogen phosphide, PH₃) or metal phosphides will produce phosphoric acid by the following reaction:

**SECTION V - REACTIVITY DATA****Stability:**

Phostoxin, DetiaPhos, Fumex and aluminum phosphide are stable to most chemical reactions, except for hydrolysis. They will react with moist air, liquid water, acids and some other liquids to produce toxic and flammable phosphine (hydrogen phosphide, PH₃) gas. Phosphine (hydrogen phosphide, PH₃) may react vigorously with oxygen and other oxidizing agents.

Incompatibility:

Avoid contact with water and oxidizing agents.

Corrosion:

Phosphine (hydrogen phosphide, PH₃) gas may react with certain metals and cause corrosion, especially at higher temperatures and relative humidities. Metals such as copper, brass and other copper alloys, and precious metals such as gold and silver are susceptible to corrosion by phosphine. Small electric motors, smoke detectors, brass sprinkler heads, batteries and battery chargers, fork lifts, temperature monitoring systems, switching gears, communication devices, computers, calculators and other electrical equipment may be damaged by this gas. Phosphine (hydrogen phosphide, PH₃) will also react with certain metallic salts and, therefore, sensitive items such as photographic film, some inorganic pigments, etc., should not be exposed.

Hazardous Polymerization:

Will not occur.

SECTION VI - HEALTH HAZARD INFORMATION**Routes of Entry:**

The dermal toxicity of aluminum phosphide is very low. The LD50 via the dermal route is estimated to be greater than 5,000 mg per kilogram for a 1-hour exposure. Primary routes of exposure are inhalation and ingestion.

Acute and Chronic Health Hazards:

Phostoxin, DetiaPhos and Fumex are highly acute toxic substances. The LC50 for phosphine (hydrogen phosphide, PH₃) gas is about 180 ppm for a one-hour inhalation exposure. The acute oral toxicity of the Phostoxin, DetiaPhos and Fumex formulations was found to be 11.5 mg/kg of body weight. Aluminum phosphide and phosphine (hydrogen phosphide, PH₃) do not cause chronic poisoning.

Carcinogenicity:

Aluminum phosphide and phosphine (hydrogen phosphide, PH₃) are not known to be carcinogenic and are not listed as such by NTP, IARC or OSHA.

Signs and Symptoms of Exposure:

Aluminum phosphide tablets, pellets, bags and dust react with moisture from the air, acids and many other liquids to release

phosphine (hydrogen phosphide, PH₃) gas. Mild exposure 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, diarrhea 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.

Emergency and First Aid Procedures:

Symptoms of overexposure are headache, dizziness, nausea, difficult breathing, vomiting, and diarrhea. In all cases of overexposure get medical attention immediately. Take victim to a doctor or emergency treatment facility.

If the gas or dust from aluminum phosphide is inhaled:

Get exposed person to fresh air. If person is not breathing, call 911 or an ambulance, then give artificial respiration, preferably by mouth to mouth, if possible. Contact a poison control center or doctor for treatment advice.

If aluminum phosphide pellets, tablets or powder are swallowed:

Call a poison control center or doctor immediately for treatment advice. Have person sip a glass of water if able to swallow. Do not give anything by mouth to an unconscious person. Do not induce vomiting unless told to by a poison control center or doctor.

If powder or granules of aluminum phosphide get on skin or clothing:

Take off contaminated clothing. Rinse skin immediately with plenty of water for 15-20 minutes. Call a poison control center or doctor for treatment advice.

If dust from pellets or tablets gets in eyes:

Hold eye open and rinse slowly and gently with water for 15-20 minutes. Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye. Call a poison control center or doctor for treatment advice.

HOTLINE NUMBER: Have the product container, label or applicator's manual with you when calling a poison control center, doctor, or when going for treatment. **CONTACT 1-800-308-4856 FOR ASSISTANCE WITH HUMAN OR ANIMAL MEDICAL EMERGENCIES.** You may also contact Degesch America, Inc..-540-234-9281/1-800-330-2525 OR CHEMTREC-1-800-424-9300 for all other chemical emergencies.

SECTION VII - PRECAUTIONS FOR SAFE HANDLING

Spill Cleanup Procedures:

If possible, dispose of spilled Phostoxin, DetiaPhos and Fumex by use according to label instructions. Freshly spilled material which has not been contaminated by water or foreign matter may be replaced into original containers. Punctured flasks or containers may be temporarily repaired using aluminum tape. If the age of the spill is unknown or if the product has been contaminated with soil, debris, water, etc., gather up the spillage in small open buckets having a capacity no larger than about 1 gallon. Do not add more than about 1 to 1.5kg (2 to 3 lbs.) to a bucket. If on-site wet deactivation is not feasible, transport the uncovered buckets in open vehicles to a suitable area. Wear gloves when handling Phostoxin tablets and pellets.

Respiratory protection may be required during cleanup of spilled material. If the concentration of phosphine (hydrogen phosphide, PH₃) is unknown, NIOSH/MSHA approved SCBA or its equivalent must be worn.

Small amounts of spillage, from about 4 to 8 kg (9 to 18 lbs.) may be spread out over the ground in an open area to be deactivated by atmospheric moisture. Alternatively, spilled Phostoxin and Fumex may be deactivated by the wet method as described in the following:

Wet Deactivation of Spilled Phostoxin and Fumex:

1. Deactivating solution is prepared by adding the appropriate amount of low sudsing detergent to water in a drum or other suitable container. A 2% solution or 4 cups of detergent in 30 gallons is suggested. The container should be filled with deactivating solution to within a few inches of the top.
2. The material is added slowly to the deactivating solution and stirred so as to thoroughly wet all of the product. This should be carried out in open air and respiratory protection may be required. At no time should the deactivation drum be covered.
3. No more than about 45 to 50 lbs. of Phostoxin, DetiaPhos or Fumex should be added to 15 gallons of water-detergent mixture. Prepacs, Ropes, and Fumex may ignite during wet deactivation if they are allowed to float to the surface. Add weights or otherwise ensure that Phostoxin and Fumex stay submerged until deactivation is completed.
4. Allow the mixture to stand, with occasional stirring, for about 36 hours. The resultant slurry of dust or packaged product will then be safe for disposal.
5. Dispose of the slurry of deactivated material, with or without preliminary decanting, at a sanitary landfill or other suitable site approved by local authorities. Where permissible, this slurry may be poured into a storm sewer or out onto the ground.

For Assistance:

Contact -

DEGESCH America, Inc.
Telephone: (540) 234-9281 / 1-800-330-2525
Fax: (540) 234-8225
Internet address: www.degeschamerica.com
E-Mail: degesch@degeschamerica.com

or

Human or Animal Emergencies – PROSAR: 1-800-308-4856
All other chemical emergencies – CHEMTREC: 1-800-424-9300

Disposal of Spent Phostoxin, DetiaPhos and Fumex:

When being disposed of, spilled or partially reacted Phostoxin, DetiaPhos and Fumex are considered hazardous wastes under existing Federal Regulations. If properly exposed, the grayish-white residual dust after a fumigation will not be a hazardous waste and normally contains only a very small amount of unreacted aluminum phosphide. This waste will be safe for disposal. However, the spent residual dust from incompletely exposed Phostoxin, DetiaPhos or Fumex may require special care.

Triple rinse tablet and pellet flasks and stoppers with water. Then offer for recycling or reconditioning, or puncture and dispose of in a sanitary landfill, or by other procedures approved by state and local authorities. Rinsate may be disposed of in a storm sewer, sanitary landfill or by other approved procedures. Or, it is permissible to remove lids and expose empty flasks to atmospheric conditions until the residue in the flasks is reacted. Then puncture and dispose of in a sanitary landfill or other approved site, or by other procedures

approved by state and local authorities. Some local and state waste disposal regulations may vary from the following recommendations. Disposal procedures should be reviewed with appropriate authorities to ensure compliance with local regulations. Contact your State Pesticide or Environmental Control Agency or Hazardous Waste Specialist at the nearest EPA Regional Office for guidance.

1. Confinement of partially spent residual materials, as in a closed container, or collection and storage of large quantities of dust may result in a fire or explosion hazard. Small amounts of phosphine (hydrogen phosphide, PH_3) may be given off from unreacted aluminum phosphide, and confinement of the gas may result in a flash.
2. In open areas, small amounts of spent residual dust or spent packaged products may be disposed of on site by burial or by spreading over the land surface away from inhabited buildings.
3. Residual dust from Phostoxin, DetiaPhos and Fumex may also be collected and disposed of at a sanitary landfill, or other approved sites or by other procedures approved by Federal, State or Local authorities.
4. From 3 to 5 kg (7 to 10 lbs.) of spent dust from 2 to 3 flasks of Phostoxin or 80 to 130 Fumex bags may be collected for disposal in a 1-gallon bucket. Larger amounts, up to about one-half case, may be collected in burlap, cotton or other types of porous cloth bags for transportation in an open vehicle to the disposal site. Do not collect dust from more than 7 flasks of tablets, 10 flasks of pellets (about 11 kg or 25 lbs.) or 300 bags in a single bag. Do not pile cloth bags together. Do not use this method for partially spent or "green" dust. Caution: Do not collect dust in large drums, dumpsters, plastic bags or other containers where confinement may occur.

Deactivation of Partially Spent Phostoxin Prepacs and Ropes and Fumex Bags:

Packaged products, such as Phostoxin Prepacs, Ropes, and Fumex bags, which are only partially spent may be rendered inactive by either a "dry" or "wet" deactivation method. The "dry" method entails holding the Prepacs, Ropes and bags out of doors in locked, 30-gallon wire baskets which are available from DEGESCH America, Inc., or your supplier. Protect the partially spent Phostoxin and Fumex from rain. The deactivated Prepacs, Ropes, and Fumex may then be taken to an approved site for burial at periodic intervals or whenever the wire container is full. Caution: Storage of partially spent Prepacs and Ropes in closed containers may result in a fire hazard upon opening the container.

Alternatively, partially spent Prepacs, Ropes and bags and residual dust from phosphine (hydrogen phosphide, PH_3) fumigations may be treated by the "wet" deactivation method as follows:

1. Deactivating solution is prepared by adding the appropriate amount of low sudsing detergent or surface active agent to water in a drum or other suitable container. A 2% solution or 4 cups of detergent in 30 gallons is suggested. The container should be filled with deactivating solution to within a few inches of the top.
2. Immerse spent Prepacs, Ropes and Fumex or slowly pour residual dust into the deactivating solution while stirring so as to thoroughly wet all of the spent material. Keep immersed for about 36 hours. This should be done in the open air and not in the fumigated structure. Dust from Phostoxin tablets or pellets should be mixed into no less than about 10 gallons of water-detergent solution for each case of spent material.
3. Dispose of the deactivated Prepacs, Ropes, and Fumex or dust-water suspension, with or without preliminary decanting, at a sanitary landfill or other suitable site approved by local authorities. Where permissible, the slurry may be poured into a storm sewer or out onto the ground.
4. Caution: Respiratory protection may be required during wet deactivation. Do not cover the container at any time. Do not dispose of dust in a toilet. Do not allow quantities of dry, spent dust from Phostoxin to be collected or stored without deactivation.

Precautions to be Taken in Handling and Storage:

Store Phostoxin, DetiaPhos and Fumex products in a locked, dry, well-ventilated area away from heat. Post as a pesticide storage area. Do not store in buildings inhabited by humans or domestic animals.

Other Precautions:

1. Do not allow water or other liquids to contact Phostoxin, DetiaPhos or Fumex.
2. Do not pile up large quantities of Phostoxin, DetiaPhos or Fumex during fumigation or disposal.
3. Once exposed, do not confine Phostoxin, DetiaPhos or Fumex or otherwise allow hydrogen phosphide concentrations to exceed the LEL.
4. Open containers of Phostoxin, DetiaPhos or Fumex only in open air. Do not open in a flammable atmosphere. Hydrogen phosphide in the head space of containers may flash upon exposure to atmospheric oxygen.
5. Phostoxin, DetiaPhos and Fumex are restricted use pesticides due to acute inhalation toxicity of highly toxic phosphine (hydrogen phosphide, PH_3) gas. For retail sale to and use only by certified applicators or persons under their direct supervision and only for those uses covered by the certified applicator's certification.
6. See EPA approved labeling for additional precautions and directions for use.

SECTION VIII - CONTROL MEASURES

Respiratory Protection:

NIOSH/MSHA approved full-face gas mask with approved canister for phosphine (hydrogen phosphide, PH_3) may be worn at concentrations up to 15 ppm. At levels above this or when the phosphine (hydrogen phosphide, PH_3) concentration is unknown, NIOSH/MSHA approved SCBA or equivalent must be worn.

Protective Clothing:

Wear dry gloves when contact with aluminum phosphide tablets, pellets or dust is likely to occur.

Eye Protection:

None required.

Ventilation:

Local ventilation is generally adequate to reduce phosphine (hydrogen phosphide, PH_3) levels in fumigated areas to below the TLV/TWA. Exhaust fans may be used to speed the aeration of silos, warehouses, shipholds, containers, etc.

We believe the statements, technical information and recommendations contained herein are reliable, but they are given without warranty or guarantee of any kind, expressed or implied, and we assume no responsibility for any loss, damage, or expense, direct or consequential, arising out of their use.



Pesticide Fact Sheet

Name of Chemical: Phosphine
Reason for Issuance: Conditional Registration
Date Issued: December 1999

DESCRIPTION OF CHEMICAL

Generic Name: Phosphine

Common Name: Phosphine gas, Hydrogen phosphide, Phosphorus trihydride

Trade Names: ECO₂FUME™

EPA Chemical Code: 066500

Chemical Abstracts
Service (CAS)

Number: 7803-51-2

Year of Initial
Registration:

1999

Pesticide Type: Insecticide

Chemical Family: Inorganic phosphine

U.S. and Foreign
Producers:

CYTEC Industries Inc
West Paterson, NJ 07424

USE PATTERNS AND FORMULATIONS

The end-use product, ECO₂FUME™ is a cylinderized, compressed gas containing a mixture of 2% phosphine by weight (2.6% by volume) in carbon dioxide (98% by weight). Carbon dioxide (in addition to being an active ingredient itself) is used as a propellant and a flame inhibitor, making the product non-flammable in air. Phosphine is a colorless gas which is odorless when pure, but technical grade material usually has an odor described as “fishy” or “garlicky”. The odor is believed to be due to the presence of substituted phosphines and diphosphines (World Health Organization, 1988). This odor cannot be relied upon as a warning of phosphine gas exposure.

Phosphine gas is used indoors to control a broad spectrum of insects for non-food/non-feed commodities in sealed containers or structures. There are no homeowner or agricultural row crop uses for this product. The end-use product is a poisonous liquefied gas under pressure, and is a Restricted Use Pesticide (RUP) due to the acute inhalation toxicity of phosphine gas. The end-use product is withdrawn from the cylinder as a liquid, but dispensed as a gas. In expanding from a liquid to a gas, it increases in volume by hundreds of times. Proper dispensing equipment and training in fumigation is necessary and required to ensure a safe and effective fumigation. During fumigation applicators must placard or post all entrances to the facility with signs warning of the presence of toxic gas. This placarding must be done in accordance with the product Application Manual.

ECO₂FUME™ is used as an aid in the control of the following insects:

Almond Moth	Angoumois Grain Moth
Bean Weevil	Cadelle
Carpet Beetle	Cereal Leaf Beetle
Cigarette Beetle	Confused Flour Beetle
Dermestid Beetle	Dried Fruit Beetle
Dried Fruit Moth	European Grain Moth
Flat grain Beetle	Fruit Fly
Granary Weevil	Greater Wax Moth
Hairy Fungus Beetle	Hessian Fly
Indian Meal Moth	Khapra Beetle
Lesser Grain Borer	Maize Weevil
Mediterranean Flour Moth	Pink Bollworm
Raisin Moth	Red Flour Beetle
Rice Weevil	Rusty Grain Beetle
Saw-toothed Grain Beetle	Spider Beetle
Tobacco Moth	Warehouse Beetle
Yellow Meal Worm	

The following non-food/non-feed items may be treated with ECO₂FUME™: Animal hide; processed or unprocessed cotton, wool or other natural fibers or cloth; clothing, feathers, furs, human hair, rubberized hair, vulcanized hair, mohair, leather products; tobacco (and tobacco products); wood, cut trees, wood chips and wood and bamboo products; paper and paper products; non-food flour; non-food starch; dried plants and flowers. There are no food or animal feed uses registered for phosphine gas (ECO₂FUME™) at this time.

The rate at which phosphine is dispensed using ECO₂FUME™ is not dependent on temperature or humidity, but on the dispensing equipment used. Unlike metal phosphide fumigants, the phosphine is not generated through a chemical reaction and both the release of the product and the termination of its administration into sealed containers or structures are instantaneous.

ECO₂FUME™ is applied at a concentration of 200-500 ppm, which is maintained for a period of 2-14 days depending upon the temperature found within the immediate surroundings of the target pest.

The use directions and limitations for this product are lengthy and detailed for this product and therefore the Agency is requiring the product to have a label and a separate Application Manual. The label and Application Manual contains numerous limitations; only the major limitations or use restrictions are included here:

1. Phosphine gas (ECO₂FUME™) is a Restricted Use Pesticide due to the acute inhalation toxicity of phosphine gas. This product is for retail sale to and use only by certified applicators for uses covered by the applicator's certification or persons trained in accordance with the manual, working under the direct supervision and in the physical presence of the applicator. Physical presence means on site or on the premises. Read and follow the label and the Application Manual which contains complete instructions for the safe use of this pesticide.
2. Worker exposure to phosphine must not exceed the 8 hour TWA of 0.3 ppm during the application or a maximum concentration of 0.3 ppm after application is completed. This includes reentry into the structure. Respiratory protection must be available at the application site.
3. Post "DANGER" signs on all entrances to fumigated areas. See the Application Manual for the specific wording required.
4. Notify appropriate company employees and provide relevant safety information (MSDS sheets, first aid procedures, etc.) to local officials annually for use in the event of an emergency.
5. Protect or remove materials containing metals such as copper, silver, gold, and their alloys and salts from corrosive exposure to phosphine. (Thus, small electric motors, smoke detectors, brass sprinkle heads, batteries, fork lifts, temperature monitoring devices, etc. Electric and

electronic equipment must be protected or removed before fumigation.)

6. Prior to applying this product, you must inspect the structure to determine if it can be made sufficiently gas tight.

This product is registered as a Restricted Use Pesticide due to its very high acute inhalation properties. Special training on how to operate the associated equipment to dispense the phosphine gas is required.

SCIENCE FINDINGS

SUMMARY SCIENCE STATEMENTS

The Agency has previously based its evaluation of fumigation usage of phosphine in the U.S. upon phosphine gas generated as the active ingredient in aluminum and magnesium phosphide. Adequate product chemistry, toxicological, ecological effects, and environmental fate data have been submitted and reviewed to support the conditional registration of ECO2FUME™ for the non-food/feed uses listed above.

ECO₂FUME™ is classified in Toxicity Category I [DANGER] based on acute effects via the inhalation route of exposure, as one would expect for a fumigation gas. Phosphine is a powerful respiratory poison. The 4-hour LC₅₀ for phosphine in rats is 11 ppm. No significant exposure to phosphine gas is expected via the oral or dermal routes. Acute inhalation toxicity exposure is the route of concern. Acute toxicity data for other routes of exposure were waived with the requirement that eye protection would be required.

In rats exposed to phosphine at 10 ppm, 6 hours/day for 3 days, there was 80% mortality in females but no mortality in males. Both sexes of rats exhibited coagulative necrosis in the tubules of the kidney and pulmonary congestion was observed in the female rats that died. A LOEL of 10 ppm for a four-week study was based on lethality (80% deaths for females) due to the sharp dose-response curve for acute toxicity. In a 13-week subchronic inhalation study, Fischer 344 rats were exposed to phosphine at levels up to and including 3.0 ppm for 6 hours/day, 5 days/week. A LOEL for subchronic exposure was not established in this study; the NOEL was 3 ppm (highest dose tested).

In a two year combined chronic/carcinogenicity study, Charles River Fischer CDF rats were exposed to phosphine gas in chambers at levels of 0, 0.3 ppm, 1 ppm and 3 ppm. There were no adverse effects observed throughout the study that was relatable to the phosphine exposures. The NOEL for this 104-week study was 3.0 ppm, the highest dose tested. The Agency does not believe that phosphine or a mixture of phosphine with carbon dioxide will pose a carcinogenic concern.

In a developmental study, pregnant CD derived Sprague Dawley female rats were exposed in

inhalation chambers to concentration of phosphine gas at levels of 0, 0.03 ppm, 0.3 ppm, 3.0 ppm, 5.0 ppm or 7.5 ppm, 6 hours per day on gestation days 6 through 15. The highest exposure group (7.5 ppm) was terminated after 10 days due to high mortalities (14/24) The only abnormalities were increased resorptions in litters of high dose (7.5 ppm) dams. Increased resorptions were not observed in the 0.3, 3.0, 5.0 ppm groups. All other observations were comparable to those for the control females and pups. The maternal NOEL is 5 ppm and the maternal LOEL is 7.5 ppm, based on the high incidence of maternal death. Although food uses are approved for certain phosphine generating fumigants (i.e., aluminum phosphide and magnesium phosphide), the general requirement for a reproductive toxicity study in rodents was waived since residues of phosphine are not expected on food or drinking water and because these developmental effects were expected to occur at doses above that at which the acute effects would result in maternal death.

Phosphine gas is not mutagenic in bacteria but is clastogenic in vitro. Negative results in an Ames test and positive results in a Chinese hamster ovary cell chromosomes assay are consistent with the in vitro test results for zinc phosphide. Studies conducted in vivo indicate that phosphine is not clastogenic in mice or rats and does not cause dominant lethal mutations in mice following exposure for up to two weeks.

Under normal environmental conditions phosphine exists as a gas. The solubility of phosphine in water at normal atmospheric pressure is approximately 340 ppm (World Health Organization, 1988) and the Ostwald solubility constant (the ratio of the concentration in solution to the concentration in the gas phase at equilibrium) is 0.201 (Fluck, 1983). Because of its high vapor pressure (40 mm Hg at -129.4 C) and Henry's Law Constant (0.1 atm m³/mol), phosphine at the soil surface is expected to rapidly dissipate into the atmosphere (World Health Organization, 1988) .

Phosphine in the atmosphere is rapidly degraded (World Health Organization, 1988). The half-life in air is approximately five hours with the mechanism of degradation being photoreaction with hydroxy radicals. The dark half-life is approximately 28 hours. The expected reaction products of phosphine in air are oxyacids of phosphorous and inorganic phosphate which are non-volatile.

Several published laboratory studies suggest that phosphine below the soil surface is quickly adsorbed and degraded (Hilton and Robinson, 1972; Eiseman et. al., 1997; Berck and Gunther, 1970). Gaseous phosphine added to soil headspace at 1000 mg/kg dry soil in closed containers degrades 50% after approximately five days in air dried soil and 11 days in water saturated soil (Hilton and Robinson, 1972). Smaller quantities of phosphine may be removed by soil through a faster mechanism because phosphine added at a lower concentration (0.35 micrograms/kg) was undetectable in 50 minutes (Eiseman, Glindemann, Bergman and Kusch, 1997). Diffusion through the soil environment is expected to be slow because phosphine is sorbed in seconds when pushed through several types of soil in a nitrogen carrier (Berck and Gunther, 1970). The interaction of phosphine with soil appears to be mixed chemisorption

(irreversible) and physisorption (reversible), with the extent of each dependent on soil type. Phosphine gas trapped below the surface will degrade to phosphates in a matter of days. Phosphine has a low exposure potential for contaminating ground and surface water.

Ecological effects or potential risk to non-targeted organisms resulting from indoor use of this fumigation gas is considered to be very minimal. Phosphine would be highly toxic to small mammals and birds that might remain in indoor sites (e.g., warehouses) during fumigation.

CHEMICAL CHARACTERISTICS

Empirical

Formula: PH₃ (CAS #: 7803-51-2)

Molecular

Weight: 34.00

Color: Colorless

Physical State: Liquefied gas under pressure
(Gas at ambient temperature and pressure)

Boiling Point: -87.4 C

Density at (20°C): 1.405 kg/M³; 1.5 relative to air at 20C/1 atm pressure

Flammability: Non-flammable at concentrations equal to or less than 3% phosphine in carbon dioxide (v/v). This product is 2.6% v/v.

Solubility in water: 0.04%

Storage stability: > 1 year

Corrosion

Characteristics: Corrodes copper, brass, copper alloys, silver and gold

TOXICOLOGY CHARACTERISTICS

ECO₂FUME™

(End-Use Product)

Acute Inhalation

Toxicity

(rats): LC50 (4-hour) > 11 ppm (phosphine gas)

Toxicity

Category: I

PHOSPHINE TECHNICAL MATERIAL

Results of studies show that phosphine gas is highly toxic by the inhalation route. Considering the use patterns and chemical characteristics, the other acute toxicity data (81-series guideline studies) were waived for this chemical. The Agency has based the assessment for acute toxicity of end-use products for phosphine fumigation (*i.e.*, ECO₂FUME, Aluminum Phosphide, Magnesium Phosphide) on exposure to the active ingredient phosphine gas, *per se*. Accordingly, the acute toxicity endpoints presented below are the same as described above for ECO₂FUME:

Acute Inhalation

Toxicity

(rats): LC₅₀ (4-hr) > 11 ppm (for phosphine gas, *per se*)

Toxicity

Category: I

Primary Eye

Irritation: Study not required, provided eye protection required.

Toxicity

Category: Not applicable.

**Repeated
Exposures,
Short-Term
Inhalation Toxicity**

3-day

inhalation (rat): (6 hours/day) LOEL 10 ppm (lethality among females)

15-day

inhalation (rat/): (6 hours/day, 5 days/week) NOAEL= 5 ppm (the highest concentration tested).

13-week

inhalation (rat): (6 hours/day, 5 days/week) NOEL= 3 ppm (the highest concentration tested)

Developmental

Toxicity (rat): The duration of exposure was 6 hours per day on gestation days 6 through 15. Maternal Toxicity NOEL=5 ppm, Maternal Toxicity LOAEL=7.5 ppm, based on a high incidence of maternal deaths.

Developmental Toxicity NOEL=5 ppm.

Reproductive

Toxicity: This study, a requirement for a food-use pesticide, was waived since residues of phosphine are not expected in food or drinking water.

Chronic Toxicity/
Carcinogenicity
(rat):

2-Year Feeding

Study: Diets were fumigated at high rates with aluminum phosphide pellets. Actual levels of phosphine in diet were unknown, due to dissipation. This study was not considered an acceptable guideline study since toxicity, resulting from phosphine residues, is not possible when aeration is adequate. However, the study shows that toxic levels of residues were not achieved even with the high fumigation treatment rates with adequate aeration.

2-Year

Inhalation

Study: In a two year combined chronic/carcinogenicity study, Charles River Fischer CDF rats were exposed to phosphine gas in chambers at levels of 0, 0.3 ppm, 1 ppm and 3 ppm. The high dose of 3 ppm was selected because higher doses would result in high mortalities from acute effects. There were no adverse effects observed throughout the study that was relatable to the phosphine exposures. The NOEL for this 104-week study was 3.0 ppm, the highest dose tested.

Acute Inhalation

Neurotoxicity

(rat): The acute LOEL is 20 ppm based on decreased body temperatures and

decreased motor activity in males and females, and the NOEL is less than 20 ppm (the lowest concentration tested). Groups were treated at levels up to and including 40 ppm of phosphine (1% a.i. in nitrogen) for 4 hours. No phosphine-related neuropathological changes were observed in any exposure group. Based on lack of systemic toxicity, the NOEL for systemic toxicity is 40 ppm.

Subchronic
Neurotoxicity
(90-day)
Inhalation
(rat):

Animals were exposed to phosphine at levels up to and including 3 ppm for 6 hours/day, 5 days/week. The NOEL for systemic/neurobehavioral effects is tentatively set at 3 ppm (the highest concentration tested); possible effects among males in the highest exposure group were considered slight and equivocal, and there did not appear to be any treatment-related effects among females. **[NOTE: An upgraded study was submitted to EPA in Sept 98; however, the Agency has not yet reviewed this study.]**

Mutagenicity

Gene mutation- Ames test (*Salmonella typhimurium*) - Negative for induction of reverse gene mutation in all strains up to cytotoxic concentrations.

Chromosome Aberrations - Positive at 2500 and 5000 ppm without S9 activation, in an *in vitro* cytogenetic assay with Chinese hamster ovary cells. Significant, but not dose-related increases in the frequency of cells with structural chromosome aberrations were found. Significant clastogenic effects were also noted at 2500 ppm with S9 activation, but not at the highest dose tested (5000 ppm).

Unscheduled DNA Synthesis (*in vivo*; rat primary hepatocytes)- Negative.

Metabolism:

This data requirement applies to food-use registrations and no food/feed uses are being registered.

Dermal

Absorption:

Because the route of exposure anticipated for phosphine is inhalation (the product is a gas), the Agency does not expect significant dermal exposure. Therefore, dermal absorption studies are not required.

Summary of Phosphide Endpoints for Risk Assessments

EXPOSURE SCENARIO	CONCENTRATION/DOSE	ENDPOINT	STUDY
Short-Intermediate or Long-Term (Dermal)	None	The use pattern does not indicate potential exposure via the dermal route. Therefore, dermal risk assessments are not required.	
Short Term (Inhalation)	0.007 mg/L (ca. 5 ppm)	No treatment-related effects after exposure for 15 days.	15-Day exposure regimen in a 90-day inhalation - Rat
	UF=100		
Intermediate (Inhalation)	NOEL= 0.004 mg/L (ca. 3 ppm)	No evidence of toxicity at the highest tested concentration.	90-Day Inhalation - Rat
	UF=100		
Long-Term (Inhalation)	NOEL= 0.004 mg/L	No evidence of toxicity at the highest tested concentration.	Chronic Toxicity Inhalation - Rat
	UF=100		

TOLERANCE ASSESSMENT

There are no food/feed uses for ECO₂FUME™ at this time. Tolerances are not required for this non-food registration. Note: Carbon dioxide is exempt from the requirement for a tolerance (40CFR180.1049).

SUMMARY OF DATA GAPS

This registration is subject, as a condition of registration, to amending the product label to include all label restrictions and/or other conditions that may be imposed on the metallic phosphide registrants, to the extent that they may also be relevant to ECO₂FUME™ and its uses. The Agency, as part of reregistration, is currently working with this metallic phosphide Task Force and other interested parties to mitigate phosphine exposure and risk to workers and bystanders.

PUBLIC INTEREST FINDING

ECO₂FUME™ is effective at controlling a broad spectrum of economically important insect pests on non-food commodities in sealed containers or structures. Under proper use conditions, ECO₂FUME™ appears to offer greater control of application rates as compared with metal phosphide fumigants, and is expected to reduce the levels of peak concentrations of phosphine necessary for satisfactory performance within fumigated areas. This product eliminates the need for applicators to enter a closed space and dispense tablets or pellets; therefore it may greatly reduce the exposure to fumigators. This product eliminates the need to dispose of waste pellets

and or tablets when using metal phosphide products. **In addition, this product may be used as an alternative to methyl bromide, a fumigation gas that depletes stratospheric ozone.**

CONTACT PERSON AT EPA

Dennis McNeilly, Chemist
Insecticide Rodenticide Branch
Registration Division (7505C)

E-Mail Address:

McNeilly.Dennis@epa.gov

Mailing Address:

U.S. Environmental Protection Agency
401 M St. S.W.
Washington DC 20460

Office Location and Telephone Number

Room 213, Crystal Mall Building #2
1921 Jefferson Davis Highway
Arlington, VA 22209
(703) 305-5404

DISCLAIMER: The information presented in this Pesticide Fact Sheet is for informational purposes only and may not be used to fill data requirements for pesticide registration and reregistration.

ANNEX T-9

REFERENCE: PHOSPHINE GAS MONITORING EQUIPMENT & RESPIRATORY PROTECTION

The following information is included in this annex:

- Proper use of the required phosphine gas monitoring equipment;
- Where and when to monitor phosphine gas;
- Types of gas monitoring equipment;
- Proper use of respiratory equipment; and

US EXPOSURE LIMITS

The short-term exposure limit (STEL) for phosphine is 1.0 ppm. Exposure limits for workers over an 8-hour work day is 1.0 ppm phosphine for 15 minutes, not to exceed 4 exposures in a single day (at least 1-hour of fresh air required between exposure periods). Workers must not be exposed to 0.3 ppm of phosphine (threshold limit value or TLV) for more than eight hours a day or 40 hours a week.

ODOR IS NOT A RELIABLE MEANS OF DETECTION

Pure phosphine is odorless; a garlic or fishy odor arises from the co-presence of diphosphane gas, which is a typical by-product of phosphane generation reactions. At typical diphosphane: phosphine ratios, the odor threshold is typically ~ 2 ppm of phosphine, which is higher than the established (STEL or TLV) safe levels. Odor cannot be used to determine if the atmosphere is safe. Safety levels can only be ascertained by monitoring for phosphine gas. This is HAZARD monitoring. Monitoring is also important to determine if phosphine levels have been maintained within an enclosure to effectively kill insects. This is EFFICACY monitoring.

PHOSPHINE GAS MONITORING EQUIPMENT

There are three basic types of units available in the market place—1) electrochemical, 2) photo-ionization, and 3) tube types.

- The electronic monitors use an electrochemical sensor in which the change in current across the sensor is proportional to the phosphine concentration in the atmosphere. The purchase price ranges from about US\$800-2,000.
- The photo ionization detectors directly measure the wavelength of a certain gas.
- The tube type devices are approximately 10 cm long and 0.5 cm in diameter with a white reactive powder inside the tube, which changes color when air containing phosphine is drawn through the tube with the aid of a handheld or mechanical pump. Tubes, with a scale in ppm of phosphine, are available for low and high range of phosphine (0.01 to 10,000 ppm), and the change in color is proportional to the phosphine concentration. Tube type devices cost about US\$200.

The electrochemical and photo ionization detectors provide continuous measurement of phosphine, whereas the tube type provides a single measurement and must be disposed of afterwards.

ELECTRO-CHEMICAL/PHOTO IONIZATION UNITS

Advantages

- Readings are presented on a digital screen.

- Alarms, both audible and visual, alert applicators that they are in an environment that exceeds the TLV for phosphine.
- If used as intended, the cost of operation is the least expensive.
- Multi-gas units can be and should be used in confined spaces; this will preclude the need for multiple monitors to check a variety of atmospheric gases.
- Replacement sensors, as well as calibration gases, are widely available (depending on the brand purchased).
- Power requirements can be as basic as multiple AA batteries.
- Readings are provided in a matter of seconds and are continuous.

Disadvantages

- A separate unit must be used if checking for high range readings in the fumigated area during the exposure period.
- The units must be calibrated every six months; the unit can be tested with a known concentration of the gas or sent back to the manufacturer for calibration.
- If the unit is to be used infrequently (no more than three fumigations/year), the purchase price and use cost may exceed that of colorimetric tubes.
- For servicing, a trained service person must be available.

COLORIMETRIC TUBES

Advantages

- Tubes can be acquired for the intended gas monitoring range (high and low range tubes)
- If only sporadic fumigations are to be done annually, this is an inexpensive alternative to electro-chemical units
- Purchase price of the pump and tubes are less than the other option

Disadvantages

- It may take several minutes to adequately characterize a specific area depending on the tube used
- Can only obtain one reading per tube, and the tube should be discarded after use
- The tubes have a defined expiration date printed on each box
- Some discoloration stains in the tube make it difficult to read
- Operators must be able to read to ensure that they are using the correct tube for the intended job

EFFICACY MONITORING EQUIPMENT

Efficacy monitoring requires “high range” sensor devices capable of reading concentration levels at or above 500 ppm. Efficacy monitoring is done using the monitoring lines placed during the sheeting operation (see Fumigation Management Plan (T-3) and Best Management Practices(T-7)).

See Annex T-7 for Efficacy Monitoring acceptable practices.

HAZARD MONITORING EQUIPMENT

Hazard monitoring requires “low range” sensors that can detect concentrations at and around the TLV limit (0.3ppm in most countries) and the STEL limit (1.0 ppm in many countries.)

Hazard monitoring must be undertaken just outside the limits of the “exclusion zone” if any bystanders/workers/residents are or are likely to be present. It should be undertaken when crews are applying fumigant and working in the warehouse with stacks under fumigation. See Annex T-7 for Hazard Monitoring acceptable practices.

DECISION CRITERIA FOR CHOOSING MONITORING EQUIPMENT

The table below should be consulted for determining the appropriate type of phosphine gas monitoring equipment for the particular situation. In addition to the below criteria, PVOs and fumigation service providers should determine whether the manufacturer is able to provide timely maintenance and parts in the host country.

Parameter	Criteria
Simplicity of operation	Ease of set-up and maintenance. If not easy to use, will employees actually use it or will the unit stay on a shelf? Is calibration required, and if so, can it be easily completed?
Reliability	Ruggedness of unit. Can it withstand impact from a fall and typical field use?
Performance features and maintenance requirements	Repeatability of gas readings Operation temperature range Response time Warranty Sensor life Battery life Approvals and certifications (such as by UL ^a) Auto zero Calibration frequency Calibration gas requirements Internal or external sampling pump
Options and accessories	Computer downloading Calibration and/or alarm check gas Remote sampling hose and/or probe
Support and service	What is the manufacturer’s track record in responding to technical questions or repair work? Can training on the unit be provided on-site, or is audio/visual material available?

^aUnited Laboratories, St. Charles, Illinois (http://www.unitedlabsinc.com/usa/content/contact_us.asp).

Source: Walter, V. 2006. Commodity and Space Fumigation in the Food Industry, pp. 183-198. In *Insect Management for Food Storage and Processing*, Second Edition, Heaps, J. W. (ed.). American Association of Cereal Chemists International, St. Paul, Minnesota, St. Paul, Minnesota.

TYPES OF GAS MONITORING EQUIPMENT



PortaSens Phosphine Monitor
(Photo Ionization Detector)



Dräger Pac III Phosphine Monitor
(Electrochemical)



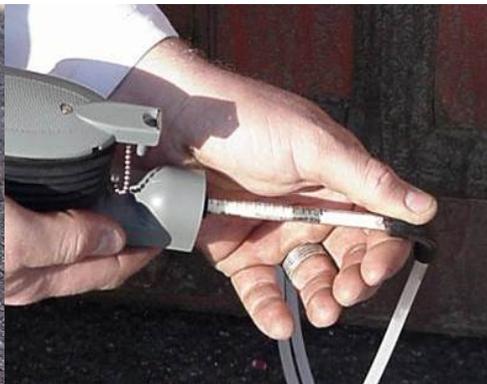
Phosphine Detector Tubes



Handheld Air Pump with Detector Tubes



Gas Monitoring Lines



Gas Monitoring Line Connected to
a Detector Tube

RESPIRATORY EQUIPMENT

Cartridge and canister type respirators or supplied air respirators with self-contained breathing apparatus (SCBA) must be used in situations where workers may be exposed to phosphine. A full-face mask must be used with both these types of respirators.

Canister type respirators are strongly preferably to cartridge-type of respirators, which should be avoided, if possible. Canister gas masks are the least expensive option. The full-face mask fit should be verified following manufacturer's instructions.

If a canister is used, it must:

- indicate that it will protect against or can be used to filter out phosphine gas.
- NOT be expired. (All manufactures print an expiration date on each canister). Canisters, even if new and unused, must be discarded if they are expired.
- ONLY be re-used up to their printed Canisters may be reused UP TO THEIR PRINTED ; and ONLY if they have been sealed and stored away from air contaminants, including phosphine gas.

REGARDLESS of what the expiration date and use log states: if, during normal use, phosphine gas odor is noticed, the canister should be discarded immediately and new one installed.

Personnel involved in fumigation and required to wear respiratory equipment must:

- be adequately trained in the donning and doffing the mask unit.
- be adequately trained in detecting leaks around the face piece.
- must not have facial hair that would prohibit an adequate mask seal.
- must be able to read and recognize the proper canister to be used as well as identifying the expiration date on the canister.

RECOMMENDED EQUIPMENT BY PHOSPHINE CONCENTRATION LEVEL

The US National Institute for Occupational Safety and Health (NIOSH) recommends the following respiratory protection at different phosphine concentrations:

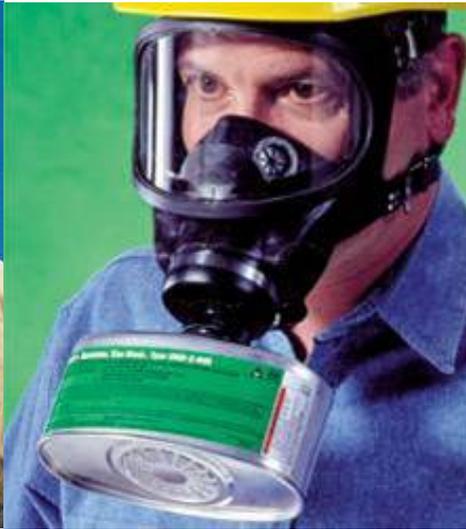
Concentration	Acceptable Equipment
3ppm or less	Supplied-air respirator
7.5ppm or less	Supplied-air respirator operated in a continuous-flow mode
15 ppm or less	Self-contained breathing apparatus with a full facepiece, or Supplied-air respirator with a full facepiece, or Air-purifying, full-facepiece respirator (gas masks) with a chin-style front- or back-mounted canister
50 ppm or less	Supplied-air respirator equipped with a full facepiece and operated in a pressure-demand mode, or Self-contained breathing apparatus equipped with a full facepiece and operated in a pressure-demand mode
Unknown	Self –contained breathing apparatus with a full facepiece

Source: NIOSH Pocket Guide to Chemical Hazards. <http://www.cdc.gov/niosh/npg/npgd0505.html>

TYPES OF RESPIRATORY PROTECTION



Air-purifying, full face-piece
Respirator



Air-purifying, full face-piece respirator
without a hose



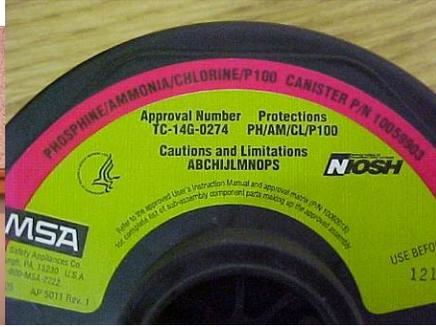
Air-purifying, half mask respirator
with canister



Supplied air respirator with full face mask



Fit Test for Cartridges to Determine Tight Fit



Read Information on Cartridges/Canisters



Self-Contained Breathing Apparatus



Face Mask Connected to SCBA

OTHER PERSONAL PROTECTIVE EQUIPMENT FOR FUMIGATION

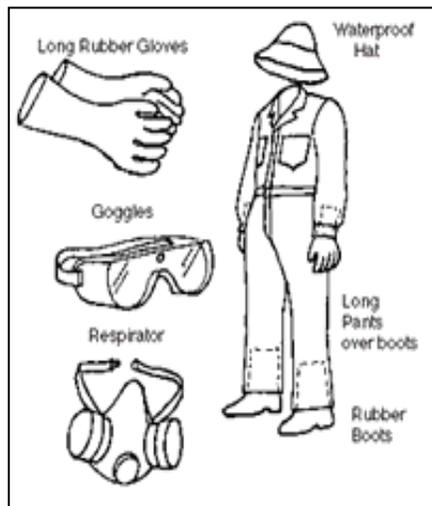


Figure 1: An assortment of personal protective clothing and

Dry cotton (or any other material) gloves, should always be worn by fumigant applicants when handling or in contact with aluminum phosphide pellets. Note that the gloves should remain dry during use. Additionally, fumigant applicators should wear rubber boots, eye goggles, and liquid-tight protective coveralls that are long sleeved, over full-length pants and long-sleeved shirts. Hands should be washed thoroughly after using aluminum phosphide. The fumigant applicant should also shower with soap as soon as possible and before changing into clean clothes. The gloves and any other protective gear/clothing should be aerated in a well-ventilated area before laundering.

Some Useful Sources for PPE Information:

- Ministry of Agriculture, British Columbia http://www.al.gov.bc.ca/pesticides/d_1.htm
- Photos courtesy of Kansas State University, Department of Grain Science and Technology from Lecture 9, Part 2 on *Fumigation Safety Considerations* by Thadd Bigler, Central States Enterprises, USA
- United Phosphorous, Inc. Rev 4/10. Applicators Manual for Aluminum Phosphide Fumigant-Tablets, Pellets and Gas Bags. s.n. USA

ANNEX T-10

REFERENCE: PHOSPHINE GAS EXPOSURE FIRST AID

SYMPTOMS OF PHOSPHINE GAS POISONING AND RESPONSE

Source: First Aid in Case of Phosphine Poisoning (<http://www.fao.org/docrep/x5042e/x5042E0a.htm>).

Develop an emergency action plan to know what needs to be done and where to seek medical care in case of poisoning.

According to the amount of phosphine inhaled, symptoms may occur immediately or several hours after exposure.

Slight or mild poisoning may give a feeling of fatigue, ringing in the ears, nausea, pressure in the chest and uneasiness. Wear Self-Contained Breathing Apparatus and move person to fresh air. Medical attention is important even in mild cases of poisoning.

Greater quantities will quickly lead to general fatigue, nausea, gastrointestinal symptoms with vomiting, stomachache, diarrhea, disturbance of equilibrium, strong pains in the chest and dyspnea (difficulty in breathing).

Very high concentrations rapidly result in strong dyspnea, cyanosis (bluish-purple skin color), agitation, ataxia (difficulty in walking or reaching), anoxia (subnormal blood oxygen content), unconsciousness and death. Death can be immediate or occur several days later due to edema and collapse of the lungs, paralysis of the respiratory system or edema of the brain. Disturbances of kidney and liver functions (hematuria, proteinuria, uremia, jaundice) and cardiac arrhythmia may occur.

There is no specific antidote for phosphine poisoning, and treatment is symptomatic.

Do not administer milk, butter or castor oil, and alcohol to affected person.

If breathing stops or shows signs of failing, resuscitation must commence immediately.

ADVICE TO THE PHYSICIAN

Manufacturers suggest the following measures for use by the physician.

- In its milder forms, symptoms of poisoning may take some time (up to 24 hours) to make their appearance, and the following measures are suggested:
 1. Complete rest for one or two days, during which the patient is kept quiet and warm.
 2. Should the patient suffer from vomiting or increased blood sugar, appropriate intravenous solutions should be administered. Treatment with oxygen breathing equipment is recommended as is the administration of cardiac and circulatory stimulants.
- In cases of severe poisoning intensive care in a hospital is recommended:
 1. Where pulmonary edema is observed, steroid therapy should be considered and close medical supervision is recommended. Blood transfusions may be necessary.
 2. In case of manifest pulmonary edema, venesection should be performed under vein pressure control, and intravenous administration of glycosides (in case of hemoconcentration, venesection may result in shock). On progressive edema of the lungs, perform immediate incubation with

constant removal of edema fluid and establishment of oxygen positive pressure respiration, as well as any measures required for shock treatment. In case of kidney failure, extracorporeal hemodialysis is necessary. There is no specific antidote known for this poison.

- In cases where solid phosphide is ingested, empty the stomach by inducing vomiting and flush it with a dilute potassium permanganate solution or a solution of magnesium peroxide until the flushing liquid ceases to smell of carbide. Thereafter, administer medicinal charcoal.
- Scientific research has shown that phosphine poisoning is not chronic; the action of phosphine is reversible and symptoms will disappear by themselves.

EXAMPLES OF DIFFERENT FIRST AID PROCEDURES IN CASE OF ACCIDENTS RESULTING FROM ALUMINUM PHOSPHIDE OR PHOSPHINE GAS

IF INHALED



1. Move person to fresh air.
2. If person is not breathing, call 911 or an ambulance, then give artificial respiration immediately, preferably by mouth-to-mouth if possible.
3. Keep warm and make sure person can breathe freely.
4. Call a poison control center or doctor for further treatment advice.

IF ON SKIN OR CLOTHING

1. Brush or shake material off clothes and shoes in a well-ventilated area.
2. Allow clothes to aerate in a ventilated area prior to laundering.
3. Do not leave contaminated clothing in occupied and/or confined areas such as automobiles, vans, motel rooms, etc.
4. Wash contaminated skin thoroughly with soap and water.

IF SWALLOWED

1. Call a poison control center or doctor immediately for treatment advice.
2. Have person drink one or two glasses of water. Do not induce vomiting unless told by a poison control center or doctor.
3. Do not give anything by mouth to an unconscious person.



IF IN EYES



1. Hold eye open and rinse slowly and gently with water for 15 – 20 minutes.
2. Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye.
3. Call poison control center or doctor for further treatment advice.

ANNEX T-11

REFERENCE: ECONOMICALLY IMPORTANT STORED-PRODUCT INSECT PESTS OF GRAIN AND GRAIN PRODUCTS

There are a number of insect species associated with stored products; the most common are presented in this Annex.

For a far comprehensive list see Hagstrum, D. W., and Bh. Subramanyam (2009). Stored-Product Insect Resource. American Association Of Cereal Chemists, St. Paul, Minnesota. Illustrations from: Hagstrum, D. W., T. Klejdysz, Bh. Subramanyam, and J. Nawrot. 2012. Atlas of Stored-Product Insects and Mites. American Association of Cereal Chemists, St. Paul, Minnesota (in press).

Order	Family name	Scientific name	Common name
Major or Primary Insect Pests			
Coleoptera	Bostrichidae	<i>Prostephanus truncatus</i> (Horn)	Larger grain borer
		<i>Rhyzopertha dominica</i> (F.)	Lesser grain borer
	Curculionidae	<i>Sitophilus granarius</i> (L.)	Granary weevil
		<i>Sitophilus oryzae</i> (L.)	Rice weevil
		<i>Sitophilus zeamais</i> (Mots.)	Maize weevil
	Laemophloeidae	<i>Cryptolestes ferrugineus</i> (Stephens)	Rusty grain beetle
		<i>Cryptolestes pusillus</i> (Schönherr)	Flat grain beetle
		<i>Cryptolestes turcicus</i> (Grouvelle)	Turkish grain beetle
	Tenebrionidae	<i>Tribolium castaneum</i> (Herbst)	Red flour beetle
		<i>Tribolium confusum</i> (Jacquelin Du Val)	Confused flour beetle
Bruchidae	<i>Callosobruchus chinensis</i> (L.)	Southern cowpea weevil	
	<i>Callosobruchus maculatus</i> (F.)	Cowpea weevil	
	<i>Acanthoscelides obtectus</i> (Say)	Bean weevil	
Anobiidae	<i>Lasioderma serricorne</i> (F.)	Cigarette beetle	
Dermestidae	<i>Trogoderma granarium</i> Everts	Khapra beetle	
	<i>Trogoderma variabile</i> Ballion	Warehouse beetle	
Silvanidae	<i>Oryzaephilus surinamensis</i> (Fauvel)	Sawtoothed grain beetle	
	<i>Oryzaephilus mercator</i> (L.)	Merchant grain beetle	
Lepidoptera	Pyralidae	<i>Cadra cautella</i> (Walker)	Almond moth

Plodia interpunctella (Hübner)
Corcyra cephalonica (Stainton)
Ephestia kuehniella (Zeller)

Indianmeal moth
Rice moth
Mediterranean flour moth

Gelechiidae

Sitotroga cerealella (Olivier)

Angoumois grain moth

The adult stages of these insects are illustrated below. Generally adult stages are easiest to identify.



Prostephanus truncatus (Horn)



Rhyzopertha dominica (F.)



Sitophilus granarius (L.)



Sitophilus oryzae (L.)



Sitophilus zeamais (Motschulsky)



Cryptolestes ferrugineus (Stephens) *Cryptolestes pusillus* (Schönerr) *Cryptolestes turcicus* (Gourville)



Tribolium castaneum (Herbst)



Tribolium confusum (Jacquelin du Val)



Callosobruchus chinensis (L.)



Callosobruchus maculatus (F.)



Acanthoscelides obtectus (Say)



Lasioderma serricorne (F.)



Trogoderma granarium Evert



Trogoderma variabile Ballion



Oryzaephilus surinamensis (Fauvel)



Oryzaephilus mercator (L.)
interpunctella (Hübner)



Cadra cautella (Walker)



Coryra cephalonica (Stainton)



Ephestia kuehniella (Zeller)



Sitotroga cerealella (Olivier)

ANNEX T-12

REFERENCE: DECIDING WHEN TO FUMIGATE

NOTE: The fumigation management plan (Annex T-3) sets out mandatory safety criteria that must be satisfied for fumigation to occur (Sections J & L). This Annex addresses how to determine when there is a NEED for fumigation to control infestation. .

THREE KEY FACTORS

The need for fumigation is influenced by three factors:

1. **Acceptability of observed insect pest levels.** The acceptable level of insect pests is based on standards established for infested grain. For example, in the US wheat with two or more live insects, on average, is considered infested. The goal for grain managers is to maintain levels below this acceptable level. “On average” is determined by the sampler taking 10 to 30 samples to determine if the average insect density is two live insects or more. If a decision to fumigate will be threshold-based, such thresholds must be developed for all food aid commodities.
2. **Suitability of the environment for pest multiplication.** Stored-product insects are cold blooded and develop faster at warmer temperatures. The optimum for rapid development (egg-to-adult, one generation) and reproduction is 28-32°C. Most countries that receive food aid have temperatures close to or greater than this optimum. Temperatures above 50°C are lethal to insects but, depending on the species, insects can do well at temperatures as high as 40°C. Under these conditions insects complete one generation in four to six weeks. Under tropical conditions, stored-product insects multiply 50-fold every six weeks, resulting in a build-up of large populations. Therefore, fumigation on a calendar basis may be the optimum to prevent pest populations from exploding. In this case, depending on site-specific warehouse situations, fumigation may be needed as often as every four to six weeks.
3. **The length of time the commodity is stored before it is shipped to beneficiaries.** Commodities stored for longer than four to six weeks can incur damage from multiplying insect populations. Therefore, quick turnover of commodities will provide less opportunity for insects to survive and thrive.

Another consideration is that sampling-based decision-making is useful when only a portion of the total storage structure will be fumigated. If the entire structure is to be fumigated, sampling adds additional costs for storehouse managers; in this case, it is more cost-effective to use a calendar-basis fumigation schedule.

DECISION GUIDANCE

The following guidelines can be used to decide when to fumigate food aid commodities.

1. Since tropical climates are conducive to year-round infestation by stored-product insects, commodities should be fumigated soon after receipt into a primary warehouse.
2. If instead, the PVO prefers to base a fumigation decision on sampling, the best point to sample is at the time of unloading from a container or truck near a primary warehouse or a port warehouse. The warehouse personnel and the PVO should decide the best method of sampling.
3. There are two types of sampling. One, a “destructive” method, requires probes to be inserted into the opened bag or bags; a handful of commodity is sampled from each. Sampling is based on examining seed slots for quality factors; insects are not sampled. If this method is used, the bagged

commodity must be re-bagged and this will take time away from unloading and loading. Table 1, below, shows the number of bags to be sampled based on the original number of bags.

4. Another approach is to conduct a visual inspection for insect infestation, primarily checking the seams of bags and the outside of bags. The number of bags to be sampled should be based on the time it takes to unload a container/truck divided by the time it takes to inspect one bag. This assumes that the inspector is trained in quickly identifying a stored-product insect from a non-stored product insect. If eggs are present inside the commodity, they can never be sampled or detected visually. Bags may be sampled at specified intervals (e.g., every 10th or 20th bag unloaded).
5. Alternatively bags can be pre-selected at time of unloading and later opened, sampled with probe, or by hand for determining infestation. This type of sampling gives a presence or absence type of information and is not threshold based. In other words, if one or more live insects are found in or on many bags, the entire lot should be fumigated upon receipt.

Table 1: Recommended Sampling Intensity for Seed in Bags^a.

# of bags	sample size	# of bags	sample size	# of bags	sample size
1 to 6	*	95 to 104	.15	195 to 204	25
7 to 14	6	105 to 114	.16	205 to 214	26
15 to 24	7	115 to 124	.17	215 to 224	27
25 to 34	8	125 to 134	.18	225 to 234	28
35 to 44	9	135 to 144	.19	235 to 244	29
45 to 54	.10	145 to 154	.20	245 to 254	30
55 to 64	.11	155 to 164	.21	255 or more	.30
65 to 74	.12	165 to 174	.22		
75 to 84	.13	175 to 184	.23		
85 to 94	.14	185 to 194	.24		

* For lots of 1 to 6 bags, sample each bag and take a total of at least 5 cores or handfuls.

Source: Knapp, A. D., T. J. Gutormson, and M. K. Misra. 1991. Seed Lot Sampling. North Central Regional Extension Publication 403, July 1991. North Dakota State University, Fargo, North Dakota.
<http://www.ag.ndsu.edu/pubs/plantsci/smgrains/ncr403w.htm>.

THRESHOLD-BASED DECISION-MAKING

The relationship between the probability of detecting an infestation or the chance of finding an infestation (P), is influenced by the number of samples (bags) observed (n) and the frequency of infestation (f). Frequency of infestation is simply the number of bags out of total unloaded that contained or had one or more live insects, inside (if it is the destructive method of sampling) or outside (if it is a non-destructive type of sampling). For example if 5 bags out of 100 had live insects the frequency of infestation is 5/100 or 0.05. The probability P ranges from 0 to 1 or 0 to 100%. These 3 variables are related as follows:

$$P(x > 0) = 1 - (1 - f)^n \quad \text{Equation 1}$$

where, P is the probability detecting 1 or more live insects (x).

In bags received recently one can expect that there may be only a few bags with live insects—inside or outside. Therefore, f may be low. In the absence of information one can assume f to be 0.01 (1 bag out of 100

has live insects), 0.05 (5 out of 100 bags has live insects) and so on. Let us assume in this example that we have $f = 5\%$ or 0.05, and $n = 30$. What is our probability of finding that infestation given 2 of the 3 variables. These calculations can be easily done in Microsoft Excel®. At any given frequency one can see the effect of taking samples (n) anywhere from 1 to 300.

$$P = 1 - (1 - 0.05)^{30}$$

$$P = 0.785 \text{ or } 78.5\%.$$

Figure 1 below shows how P changes at different f values. Generally, as the frequency of infestation is greater (more bags have insects), one would need only a few bags to inspect or have greater confidence or probability. Conversely, the graphs can also be used to set a confidence level or probability at 0.95 or 95% and determine how many samples are needed to be sure that you are able to detect insects at a certain f .

The number of samples to be taken is based on time available for the sampler and a method highlighted in bold above. Time and resources are always limited so one cannot sample all the bags. Equation 1 above can be rearranged to find n for a given P and f and f for a given P and n . These will be illustrated below.

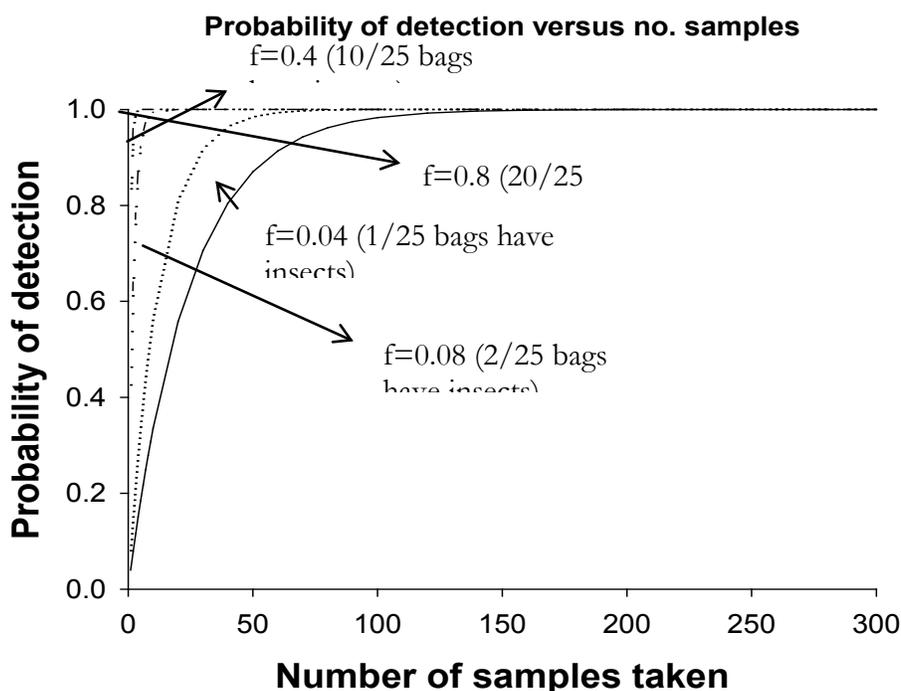


Figure 1. Relationship between Probability of Detection, Number of Samples, and Frequency of Infestation. The Inset Graph Shows the Same Four Lines Over 0 to 50 Samples.

Equation 1 can be rearranged to find how many samples are needed (n) given P and f . Assume that you want to be 95% sure ($P = 0.95$) that you want to detect an infestation rate of 5% ($f = 0.05$). How many samples or bags should be inspected?

$$n = \ln[1 - P] / \ln[1 - f] \quad \text{Equation 2}$$

$$n = \ln[1 - 0.95] / \ln[1 - 0.05] = 58.4 \text{ or } 58 \text{ samples/bags}$$

If your warehouse has a policy to inspect only a certain number of bags, we can determine what level of infestation frequency (f) you will be able to find. Let us assume for this exercise that your $P = 0.95$, and n is 30 bags.

Rearranging Equation 1 then yields, $f = 1 - [1 - P]^{1/n}$ Equation 3

$$f = 1 - [1 - 0.95]^{1/30} = 0.095 \text{ or } 0.095 \times 100 = 9.5\% \text{ or approximately } 10\%.$$

This value is the maximum infestation frequency (f_{\max}) I should have in order to be 95% sure that if I take 30 bags I will find an infestation. The true frequency may lie anywhere between >0 to 9.5%!

These same calculations can also be used when visually inspecting or sampling bags after the bags are placed in stacks over pallets. However, it is important to realize that only the bags on the exterior and top can be sampled and not those inside or inaccessible. One can also use the same techniques when inspecting various portions of a warehouse. In order to use these equations for warehouse inspections one has to define different zones of the warehouse or divide it into a certain number of equal quadrats or zones. The number of zones with a live insect should then be recorded.

Irrespective of whether bags are sampled or floors or underneath pallets are examined, the number of locations out of total examined with a live insect should be recorded to use the above equations. The frequency of infestation may also vary by month. The tools above provide some quantitative basis to make a decision to fumigate.

USE OF TRAPS VS VISUAL INSPECTIONS OR SAMPLING

Sometimes visual inspections or sampling can be deceptive, because insects may not be active at the time the inspector is sampling. In such situations, the use of devices such as food-baited and pheromone traps for various stored-product insects is best. These devices work 24 hours a day, 7 days a week and work on insect behavior.

Insects are attracted to the traps and are captured in the traps. It is also possible for these traps to detect insects that may be attracted from the outside. The food-baited traps are for crawling insects (Figure 2) while traps with pheromones with sticky bottoms (Figure 3) are for flying insects.

Since these traps work on insect behavior, absence of insects does not mean that insects are absent; all it means is that insects failed to come to the trap and be captured. Fast moving insects are likely to be captured more than slow moving insects. The fact that these devices sample continuously 24 hours a day, 7 days a week helps increase the probability of detecting insects.

How can one use trap data to make a decision to fumigate? The warehouse manager or PVO must place 30-40 traps in each warehouse and examine them on a weekly basis. All captured stored-product insects should be sorted by species and counted. If a few traps out of the total deployed have insects then it can be assumed that the infestation is not severe.

On the contrary, if every trap has an insect then there is a widespread problem. Managers can set an arbitrary threshold to fumigate when 10, 20, or 30 percent of traps have insects. Also, the traps can be used after fumigation to determine the degree and duration of control achieved or the need for the next fumigation.

The trap data should be correlated with visual inspection data. The only limitation of traps is that the food baits and lures should be replaced at monthly intervals.



Figure 2. Food-Baited Traps with Oil and Lures for Three Insect Species For Capturing Crawling Insect Species (Photo: Bh. Subramanyam). These Traps Should be Placed in a Grid Fashion Throughout the Warehouse. They Can Also be Placed Outdoors.



Figure 3. Sticky Traps with a Lure (Red Rubber Septum) for Capturing Flying Insects. These Traps Should be Hung at Eye Level to a Suitable Structure in a Warehouse. They Can Also be Used Outdoors.

IN SUMMARY

There is no simple answer to know when to fumigate. It can be done on a calendar basis, every 4-6 weeks as a precautionary measure, or through visual inspections, or sampling using insect traps and some arbitrarily set threshold of one or more live insects or percentage of traps with insects. It is always important to accumulate any visual and trap information for review and refinement of pest management decisions.

ANNEX T-13

REFERENCE: TRAINING AND EDUCATION MATERIALS ON PHOSPHINE FUMIGATION AND FOOD PROTECTION

PHOSPHINE FUMIGATION GUIDES

Suggested Recommendations for the Fumigation of Grain in the ASEAN Region. Part 1. Principles and General Practice. 1989. ASEAN Food Handling Bureau, Kuala Lumpur, Australian Centre for International Agricultural Research, Canberra, Australia.

Boye, J., S. Ignatowicz, H. Lange, O. Mück, D. K. Mueller, S. Navarro, and V. Sotiroidas. 2006. Training and Technical Support in Alternative Technologies to Methyl Bromide Fumigation for Post-Harvest Sector in CEIT Countries. United Nations Environmental Program, Training Manual.

<http://jp1.estis.net/includes/file.asp?site=ecanetwork&file=8AA139BF-610D-4524-8BB1-8003850B52C1>
(Excellent source of information on integrated pest management)

Fumigation Training Manual, University of Kentucky Cooperative Extension Service, Lexington, Kentucky.
<http://pest.ca.uky.edu/PSEP/Manuals/7c-FumigationManual.pdf>

van Someran Graver, J. E. 2004. *Guide to Fumigation Under Gas-Proof Sheets*. Food and Agriculture Organization of the United Nations. Produced by the Australian Centre for International Agricultural Research, Canberra, Australia. Available at

http://www.fao.org/inpho_archive/content/documents/vlibrary/ad416e/FAOHomeIndex.htm (on-line e-book; includes accompanying videos) and

<http://http://aciarc.gov.au/files/node/543/FAO%20full%20text.pdf> (print-ready PDF).

The best resource for conducting fumigation.

Flander K., and S. Brown. 2005. Fumigating Agricultural Commodities with Phosphine, Alabama Cooperative Extension System, Auburn University, Alabama. <http://www.aces.edu/pubs/docs/A/ANR-1154/>

Warrick, C. 2011. A Grains Industry Guide: Fumigating with phosphine, other fumigants and controlled atmospheres. Grains Research and Development Corporation. GRDC Grain Storage and Extension Project, Australia. <http://www.chemcert.com.au/2012/PDF/National/Phosphine/GRDC%20Phos.pdf>

Manual of Fumigation for Insect Control. FAO Corporate Document Repository, Rome Italy.

<http://www.fao.org/docrep/x5042e/x5042E0a.htm>

NIOSH Alert: Preventing Phosphine Poisoning and Explosions During Fumigation. 1999. Department of Health and Human Services (NIOSH) Publication No. 99-126, National Institute for Occupational Safety and Health Publications Dissemination,

Cincinnati, Ohio. <http://www.cdc.gov/niosh/docs/99-126/>

Dangerous Phosphine Practices in West Africa. <http://www.pan-uk.org/pestnews/Issue/pn53/pn53p4.htm>

FUMIGATION TRAINING VIDEOS

Fumigation Management Plan Resources for Aluminum Phosphine. North Dakota State University Extension Service Pesticide Program, Fargo, North Dakota.

http://www.ag.ndsu.nodak.edu/aginfo/pesticid/fum_resource.htm. This link has videos on phosphine fumigation.

PHOSPHINE GAS MONITORING DEVICES AND RESPIRATORY PROTECTION

Cardinal Professional Products, Woodland, California. Labels and MSDS of Pesticides for Insect and Vertebrates Pests, Gas Monitoring Equipment, Respiratory Protection, and Training in Fumigation. <http://www.cardinalproducts.com/>

Ribble Enviro Ltd. Gas Detection Equipment. http://www.ribble-enviro.co.uk/product/drager-detection-tubes.htm?gclid=CNf_hM_b2LACFVPftgodvWEc2Q

DegeschAmerica, Inc. Weyeres Cave, Virginia. <http://www.degeschamerica.com/products.asp>

Uniphos Gas Detector Tube and Pump Accuracy. Technical Note 02, January 2, 2012. <http://www.factorydirectsafety.com/assets/tech-notes/TN-02-Detector-Tube-Accuracy.pdf>

Uniphos, United Phosphorus Limited, Maharashtra, India. <http://www.uniphos-she.com/>

Grainger. Gas Detection Equipment. <http://www.grainger.com/Grainger/gas-detection/safety/ecatalog/N-b0s>

ControlEquipment Private Limited, Australia. <http://www.contralequipment.com.au/>

Intrinsically Safe Personal Gas Detectors. SA Ex Instruments (Pty) Ltd., Wellington 7655, Western Cape, South Africa. <http://www.intrinsically-safe-instruments.com/gas-detectors.html>

Danley, R., B. Adam, J. Criswell, R. Noyes, and T. W. Phillips. 2005. How Accurate Are Phosphine Monitoring Devices? Journal of Pesticide Safety Education 7: 1-9. http://scholar.lib.vt.edu/ejournals/JPSE/v7/JPSEV7_1-9.pdf

National Pesticide Applicator Certification Core Manual. <http://www.nasda.org/workersafety/>. There are 12 Chapters. Chapter 6 is dedicated to Personal Protective Equipment.

Department of Labor, Occupational Safety, and Health Administration. <http://www.osha.gov/pls/publications/publication.AthruZ?pType=AthruZ#R>. Scroll down to Respiratory Protection Standard: Small Entity Compliance Guide

Airgas. Respiratory Protection Equipment Company. http://www.airgas.com/browse/category_list.aspx?catID=177&WT.svl=177&gclid=CJDVuf_N2rACFSdeTAodbVGY0w

Respirator Protection Center. Respirators, Cartridges, and Filters. <http://www.respiratormaskprotection.com/index.html>

End-of-Service-Life Calculator for Cartridge and Canister Respirators. <http://northsafety.com/> Click on U.S. map. Then click on “Selection Guide for Respiratory and Hand Protection” on the left. Then click on “Cartridge Service Life Estimation” at top.

STORED-PRODUCT INSECTS

List of Stored Product Insect Websites. http://www.ksre.ksu.edu/grsc_subi/Database/SPI_websites/Stored_product_insect_website1.htm

Kansas State University. Postharvest Protection Website. http://www.ksre.ksu.edu/grsc_subi/. Has power point files on stored product insects and their management.

Primary Insect Species. Canadian Grain Commission. <http://www.grainscanada.gc.ca/storage-entrepote/pip-irp/pip-irp-eng.htm>

USDA-ARS, Stored-Product Insect Images. http://bru.gmpcr.ksu.edu/db/insect/search_results.asp

Stored-Product Insects. Cardinal Professional Products, Woodland, California. <http://cardinalproproducts.com/wp/stored-product-insects/>

Hagstrum, D. W., and Bh. Subramanyam. 2009. Stored-Product Insect Resource. American Association of Cereal Chemists International, St. Paul, Minnesota. <http://www.apsnet.org/apsstore/shopapspress/Pages/27663.aspx>

Reichmuth, C., M. Schöller, and C. Ulrichs. 2007. Stored Product Pests in Grain: Morphology, Biology, Damage, and Control. AgroConcept Verlagsgesellschaft, Bonn, Germany.

Hagstrum, D. W., and Bh. Subramanyam. 2006. Fundamentals of Stored-Product Entomology. American Association of Cereal Chemists International, St. Paul, Minnesota. <http://www.amazon.com/Fundamentals-Stored-Product-Entomology-David-Hagstrum/dp/1891127500>

Subramanyam, Bh., and D. W. Hagstrum (ed.). 2000. Alternatives to Pesticides in Stored Product IPM. Kluwer Academic Publishers, Boston, Massachusetts. <http://www.amazon.com/Alternatives-Pesticides-Stored-Product-Bhadriraju-Subramanyam/dp/0792379764>

Subramanyam, Bh., and D. W. Hagstrum. 1996. Integrated Management of Insects in Stored Products, Marcel Dekker, New York.

Dobie, P., and C. P. Haines. 1991. Insects and Arachnids of Tropical Stored Products, Second Edition. Natural Resources Institute, Chatham, U.K. <http://www.amazon.co.uk/Insects-Arachnids-Tropical-Stored-Products/dp/0859542823>

Sinha, R. N., and F. L. Watters. Insect Pests of Flour Mills, Grain Elevators, and Feed Mills and Their Control. 1985. Research Branch Agriculture Canada, Publication 1776. Canadian Government Publishing Centre, Ottawa, Canada.

DISTANCE EDUCATION COURSE ON MANAGING STORED GRAIN INSECTS

Grain Elevators and Processing Society (GEAPS) Distance Education Course on, “Management of Insect Pests in Stored Grains”. Offered in Spring Every Year. Limited to 30-40 participants. http://www.geaps.com/knowledge/dist_learn/course_525.cfm

STORED-PRODUCT INSECT MONITORING DEVICES (NOT FOR CONTROL)

AgriSense, South Wales, U.K. http://www.agrisense.co.uk/ProdRange_ipc.php

Click on Products and Select Traps for Stored-Product Beetles and Moths.

Trécé, Inc., Adair, Oklahoma. <http://www.trece.com/> The Company Has a Wide Range of Products for Monitoring Stored-Product Insects in Warehouses and Commodities.