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AGRICULTURAL COMMODITY PROTECTION BY PHOSPHINE FUMIGATION PROGRAMMATIC ENVIRONMENTAL ASSESSMENT



NOVEMBER 2013

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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

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LIST OF ACRONYMS

ACDI/VOCA	Agricultural Cooperative Development International and Volunteers in Overseas Cooperative Assistance
AchE	Acetyl cholinesterase
AE	Aerosol
AI	Active Ingredient
APHIS	Animal and Plant Health Inspection Service (USDA)
ARS	Agricultural Research Service
BEO	Bureau Environmental Officer (USAID)
BEST	Bellmon Estimation Studies for Title II project (USAID)
BP	Best Practices
BFS	Bureau for Food Security (USAID)
CA	Certified Applicator
CATAMA	Committee on Aviation Toxicology, Aero Medical Association
CCC	Commodity Credit Corporation
CFR	Code of Federal Regulations (US)
CCOHS	Canadian Centre for Occupational Health and Safety
CO ₂	Carbon dioxide
CRG	Commodity Reference Guide
CRS	Catholic Relief Services
CSB	Corn soy blend
DCHA	Bureau for Democracy, Conflict & Humanitarian Assistance (USAID)
DHHS	Department of Health and Human Services (US)
EC	Emulsifiable Concentrate
EWG	Environmental Working Group (USAID)
ESR	Environmental Status Report
FACG	Food Aid Consultative Group
FAO	Food and Agricultural Organization of the United Nations
FAS	Foreign Agricultural Service
FDA	Food and Drug Administration (DHHS)
FFP	Food for Peace (USAID)
FGIS	Federal Grain Inspection Service (US)
FGPFS	Food Grain Protection and Fumigation Specialist
FHI	Food for the Hungry International or Feed the Hungry International
FMP	Fumigation Management Plan
FSA	Farm Service Agency (USDA)
FSP	Fumigation service provider
FtF	Feed the Future (USAID)
FY	Fiscal Year
GAO	Government Accountability Office (US)
GEMS	Global Environmental Management Support
GMO	Genetically modified organism
GUP	General Use Pesticide
HDPE	High density polyethylene
HHRE	Human Health Risk Evaluation
IEE	Initial Environmental Examination
IFADC	International Food Aid and Development Conference
IGR	Insect Growth Regulator
IO	International organization
IPM	Integrated Pest Management

IRIS	Integrated Risk Information System
ITSH	Internal Transport, Shipping and Handling
KCCO	Kansas City Commodity Office
LOE	Level of Effort
MAAIF	Ministry of Agriculture, Animal Industry and Fisheries (Uganda)
MSHA	Mine Safety and Health Administration (US)
MOE	Margin of Exposure
MT	Metric Ton
N ₂	Nitrogen
NGO	Non-Governmental Organization
NIOSH	National Institute for Occupational Safety and Health (US)
NOAEL	No Observed Adverse Effect Level
O ₂	Oxygen
OSHA	Occupational Safety and Health Administration (US)
PBO	piperonyl butoxide
PEA	Programmatic Environmental Assessment
PEL	Permissible Exposure Limit
PERSUAP	Pesticide Evaluation Report and Safe Use Action Plan
P.L. 480	Public Law 480 (US)
Ppb	Parts per billion
PPE	Personal protective equipment
Ppm	Parts per million
PSA	Participatory Stakeholder Analyst
PVC	Poly vinyl chloride
PVO	Private Voluntary Organization
RED	Reregistration Eligibility Decision (published by USEPA)
RUP	Restricted Use Pesticide
SC	Soluble Concentrate
SIA	Social Impact Assessment
SOP	Standard Operating Procedure
SOW	Scope of Work
UN	United Nations
UNESCO	United Nations Education, Scientific and Cultural Organization
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USDHHS	United States Department of Health and Human Services
WBSCM	Web Based Supply Chain Management
WFP	World Food Programme (of the UN)
WP	Wettable Powder
WV	World Vision

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SUMMARY

PURPOSE OF THE PROGRAMMATIC ENVIRONMENTAL ASSESSMENT

The United States Government (USG) is committed to the promotion of global food security through its international food assistance and other foreign assistance programs. The US Agency for International Development's Bureau for Democracy, Conflict and Humanitarian Assistance, Office of Food for Peace (USAID/DCHA/FFP) contributes to this commitment by working to minimize hunger in the world so that people everywhere can enjoy active and productive lives, and ultimately, to ensure that one day food aid is unnecessary.

USAID's FFP Program works toward a world free of hunger and poverty, where people live in dignity, peace, and security. To this end, the FFP office, through funding provided by the 2008 Farm Bill through Title II of the Food for Peace Act, makes agricultural commodity donations to private voluntary organizations (PVOs) and international organizations (IOs) such as the UN's World Food Program [WFP]. These resources directly address food insecurity and provide emergency food aid.

The Title II supply and distribution chain is complicated and involves many parties in the US and internationally. Title II commodities are purchased from US farmers and shipped abroad from US ports on the east coast, west coast, Great Lakes, and Gulf of Mexico. Transit time from port to port varies from approximately 2 weeks to 2 months, as disruptions of the logistics chain can take place. Upon arrival at the host country port of entry, food aid may remain on the vessel while other high-priority commodities are cleared at port. Based on interviews with the port authorities and supply chain managers, delays can occur as a result of constraints along the distribution chain, such as a country's port facility capacity, availability of trucks, and the demand for materials such as fertilizers and cement. Alternatively, food may immediately be unloaded from the vessel yet stored for longer than expected (i.e., more than 15 days) at a port facility due to shortages of trucks or warehouse space. Additionally, once commodities arrive at a PVOs' primary and secondary warehouses, there may be further delays in distribution, during which time insect infestation can occur. Once at the local distribution point, food aid is generally quickly distributed to beneficiary communities, where infestation is less likely to occur. Delays in distribution could predispose food aid commodities to infestation and spoilage, especially by insects hatching from stored-products; therefore, fumigation is an important tool to prevent loss.

The need for this PEA was clearly stated in the *USAID 2011 Scoping Statement for the Programmatic Environmental Assessment for Title II Food Aid Commodity Protection and Fumigation*, which is the primary guiding document for the PEA. Most Title II commodities, with the exception of tinned food aid commodities such as vegetable oil, are fumigated with pesticides as they are prepared for shipment from the US, during transit and local storage, or upon arrival in port. As with any program involving post-harvest storage of an agricultural commodity, Title II food aid may become infested with common pests such as weevils, grain borers, flour beetles, mites, moth larvae, mice, and rats. Prevention and control of pest intervention in food aid commodities is critical to delivering food to those most in need. As such, FFP partners and producers, commercial silo managers, handlers, shippers, and commodity brokers commonly rely on fumigants, contact insecticides, and rodenticides to prevent or minimize the loss of valuable commodity (USAID, 2006).

The issue of fumigation for USG food aid commodities requires thorough analysis by USAID, other donors, the United Nations (UN) or non-government organizations (NGOs). The existing USAID guidelines in the Commodities Reference Guide are a critical source of information but not necessarily applicable for practical use in host countries because of logistically difficult conditions. Different partners are using distinct approaches with varying degrees of sophistication that are not fully effective in ridding the food aid of insect pests. There is also a concern that some commodities may be exposed to an excessive number of fumigation cycles. Furthermore, FFP partners have had to destroy hundreds of metric tons of commodity due to infestation. In addition to preventing food from reaching malnourished and critically food insecure

beneficiaries, disposing of large quantities of spoiled or contaminated food aid is an environmental management challenge.

The purposes of this PEA are to guide those involved in Title II food aid, whether representing USAID or its PVOs, to:

- Bring the Public Law(PL) 480, Title II program into overall compliance under the precepts of the Agency’s environmental regulations;
- Identify the potential for adverse human health and environmental impacts from fumigation of food aid and recommend mitigation and monitoring measures to counter them;
- Develop tools and guidance that will lead to safer fumigation procedures and thus safeguard food aid quality, protect human health, and mitigate adverse environmental impacts; and
- Build capacity for best management practices related to food aid protection via integrated pest management (IPM) and fumigation across the full array of stakeholders involved in Title II food aid.

Partner compliance requirements are synthesized in the Tools Annexes; partners that follow instructions in the Tools Annexes will satisfy the requirements of the PEA.

APPROACH OF THE PEA

The approach for this PEA was developed based on the findings of the *USAID 2011 Scoping Statement for the Programmatic Environmental Assessment for Title II Food Aid Commodity Protection and Fumigation*. The Scoping Statement included a desk study and stakeholder consultation with USAID FFP/Washington DC, the PVOs headquarters food aid experts, the Food Aid Consultative Group (FACG), and the Environmental Working Group (EWG). The results of the Scoping Statement outlined the context in which fumigation is used, identified existing knowledge gaps, and answered preliminary questions on the protection and management of food aid commodities from procurement to distribution, with particular attention to fumigation practices. The PEA approach was then refined based on the Scoping Statement data and field work was planned accordingly, as shown in Figure E-1.

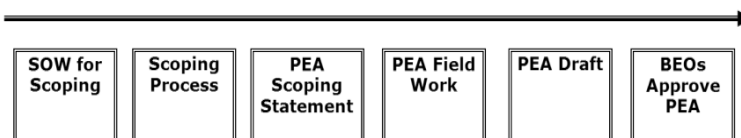


Figure E-1 – Logic pathway for scoping and completion of PEA.

The PEA Team composition consisted of the following specialists:

- Team Leader/Environmental Review Specialist
- Food Grain Protection and Fumigation (FGPF)/IPM Specialist
- Participatory Stakeholder Analyst (PSA)/NGO Liaison
- Social Impact Assessment (SIA) Specialist
- Technical Quality Control/Quality Assurance Specialist
- Human Health Risk Evaluator

The core team, comprising the team leader, FGPF, and PSA, conducted field visits and stakeholder interviews before preparing the draft PEA report. The SIA Specialist served as an advisor and reviewed the draft PEA. The Technical Quality Control Specialist served as an advisor, primary reviewer, and PEA author.

A concern raised during the Scoping process for the PEA was whether dangerous residues of the fumigant could remain on food aid destined to be consumed by project beneficiaries. To address this issue, the PEA process included the preparation of a Human Health Risk Evaluation (HHRE) to assess the risks from the use of the fumigant, phosphine gas (hydrogen phosphide), at warehouses where USAID FFP food aid commodities were being stored. The HHRE provides semi-quantitative and qualitative estimations of potential risk to human health that may result from phosphine fumigation practices. The PEA used the HHRE as a basis for identifying potential impacts to the health of fumigators, other on-site warehouse workers, warehouse visitors, beneficiaries, and nearby residents.

The PEA process was largely informed by stakeholder consultations in the US and USAID partner countries. Extensive stakeholder consultations were also conducted in Washington DC prior to field visits. These planning sessions included stakeholders throughout the food aid commodity chain, from procurement of food to distribution to beneficiaries. Stakeholders included PVO headquarters' staff, the World Food Program (WFP), transporters, fumigation consultants, commodity suppliers, and logistics experts. The Washington DC engagements provided focus in framing the questions for the field visits, site selection, and PVO in-country coordination. The engagements also gave stakeholders a forum for voicing their organization's concerns and questions. During field visits to Uganda, Ethiopia, and Djibouti, the PEA Team met with USAID Missions, PVOs, fumigation service providers, port authorities (Djibouti), warehouse managers (pre-positioning warehouse in Djibouti), and transporters and surveyors of Title II food aid to discuss processes, logistics, and contracting for each supply chain.

The PEA Scoping Statement identified alternatives to fumigation and key issues to be evaluated in the PEA. Based on review during the PEA process, for a number of reasons the PEA Team revised the initial alternatives as well as the evaluation of critical issues. The analysis of the alternatives' potential impacts constitutes the foundation of the PEA mitigation measures (the Programmatic Environmental Mitigation & Monitoring Plan).

FINDINGS OF THE PEA

The following notes present the major issues addressed in the PEA and the primary findings for the use of fumigants in Title II food aid fumigation.

Issue 1: Use of the fumigant aluminum phosphide, and to a lesser extent magnesium phosphide, can potentially affect the health of applicators and other on-site workers and visitors.

Aluminum phosphide can produce phosphine gas when exposed to ambient air. The potential for acute exposure to applicators and other on-site workers, including loaders and transporters, poses a possible health concern without appropriate safety equipment. The potential for chronic exposure may exist, and precautions should be taken to ensure fumigant applicators and other on-site workers do not suffer adverse chronic effects. Mitigation is needed to minimize the potential impacts associated with acute exposure and reduce the potential for chronic exposures.

Issue 2: Use of the fumigant phosphine gas can affect the health of residents near warehouses being fumigated.

Potential acute and chronic health impacts to nearby residents could result from exposure to phosphine gas emanating from warehouses during fumigation. Mitigation measures should be designed on a case-by-case basis within a delimited area, and should take into account any potential exposure to nearby residents.

Issue 3: The quality of the food commodity may be compromised due to phosphine fumigation.

The study of the impact of phosphine fumigation on food quality is ongoing. Conflicting studies exist regarding the impact of fumigants on food quality, with most findings inconclusive. However, the no-use alternative could have significant implications when it comes to potential for infestation, mycotoxins contamination, and the risk of losing the commodity if it is not fumigated. Safeguards to minimize concerns are available and easily implemented.

Issue 4: Beneficiary populations may be at risk from inhalation, preparation, and ingestion of fumigated commodities.

Based on the current state of knowledge, including the finding from the HHRE that there is a potential for residues on commodities, risks to beneficiaries may exist. Mitigation can minimize potential adverse effects; however, additional research is needed to determine health risks, if any, to USAID Title II beneficiaries.

Issue 5: Phosphine fumigation residuals could affect water quality, soil, and non-target organisms.

The greatest concern for environmental contamination is if spent aluminum phosphide residues (usually containing 3% - 5% phosphine) are not properly managed for disposal. In addition, dispersal of phosphine gas from the site could impact non-target organisms. As such, mitigation to limit environmental contamination is needed.

Issue 6: Poor practices in transport, storage, and disposal of fumigants are a concern for human health

In Title II recipient countries, safeguards may not be in place to ensure proper handling of fumigants (during transport, storage, and disposal). Poorly handled solid waste, such as combining various types of waste, including aluminum and magnesium phosphide residues/byproducts, could present a danger. However, by implementing simple best practices, adverse impacts from improper handling can be avoided.

Issue 7: Improper disposal practices of rodents and birds killed by phosphine gas could affect human health.

Proper practices for rodent and bird disposal, as well as measures for excluding rodents and birds from warehouses, can be implemented to minimize risks.

Issue 8: Phosphine may not completely control fungal contamination.

While phosphine gas should limit fungal contamination, it may only be effective for certain fungal species. Laboratory trials suggest that phosphine fumigation may limit mold development and mycotoxin production, but after the gas dissipates, fungal growth and mycotoxin production may reoccur. The only reliable measure to protect against fungal growth is to purchase commodity that is at 13% or less moisture, and distribute it as quickly as possible.

PROCEDURES AND USE OF THE PEA

In accordance with USAID's Pesticide Procedures, the "procurement or use" of any pesticides for USAID Title II programs requires that an Initial Environmental Examination (IEE) be in place along with a Pesticide Evaluation Report and Safe Use Action Plan (PERSUAP), which includes 12 factors outlined in the Pesticide Procedures described in 22 CFR 216.3 (b)(1)(i) (a through l). The PERSUAP focuses on the particular

circumstances of the program in question, the risk management choices available, and how a risk management plan would be implemented in the field.

A PERSUAP consists of two components, a “PER” and a “SUAP” (see Annex T-2 for an annotated template of a PERSUAP for aluminum phosphide). The Pesticide Evaluation Report (PER) section addresses the 12 informational elements required in the Agency’s Pesticide Procedures. The Safer Use Action Plan (SUAP) puts the conclusions reached in the PER into a plan of action, including assignment of responsibility to appropriate parties connected with the pesticide program (<http://www.usaid.gov/results-and-data/information-resources>).

Currently, as part of their environmental compliance documentation, an evaluation of user hazard is required of all Title II PVOs who provide assistance for the procurement or use of aluminum or magnesium phosphides. However, once DCHA BEO approval of this PEA is obtained, due to its programmatic nature, the evaluation of user hazard contained in Section 5, issues #1-4 (as well as the full HHRE) should satisfy the requirement for each PVO to prepare an individual evaluation of user hazard. This PEA (and the corresponding HHRE) is intended to satisfy the Reg. 216 requirement for an evaluation of user hazard. The preparation of a PERSUAP gives a program manager the opportunity to consider practical actions to reduce the risks of using pesticide products in a program, taking into consideration the context in which the products will be used, the particular elements of the program, and the different capacities of the partners involved.



INTRODUCTION

The United States (US) is committed to the promotion of global food security through its international food assistance and other foreign assistance programs. The US Agency for International Development's Office of Food for Peace, within the Bureau for Democracy, Conflict and Humanitarian Assistance (USAID/DCHA/FFP), contributes to this commitment by working to minimize hunger in the world so that people everywhere can enjoy active and productive lives, and ultimately, to ensure that one day food aid is unnecessary.

USAID's FFP Program works toward a world free of hunger and poverty, where people live in dignity, peace, and security. To this end, the FFP office, through funding provided by the 2008 Farm Bill through Title II of the Food for Peace Act, makes agricultural commodity donations to private voluntary organizations (PVOs) and international organizations (IOs) like the UN's World Food Program [WFP]). These resources directly address food insecurity and provide emergency food aid.

I.I. PURPOSE OF THE PEA

The USAID Title II food aid programs have a complicated supply and distribution chain that involves many parties in the US and internationally. Title II commodities are purchased from US farmers and then shipped from US ports on the east coast, west coast, Great Lakes, and Gulf of Mexico. Transit time from port to port varies from approximately 2 weeks to 2 months as disruptions of the logistics chain can take place. Upon arrival at the host country port of entry, food aid may remain on the vessel while other high-priority commodities are cleared at port. Based on interviews with the port authorities and supply chain managers, the delay is dependent on constraints along the distribution chain, such as a country's port facility capacity, availability of trucks, and the demand for other materials, such as fertilizers and cement. Alternatively, food may be unloaded from the vessel, yet may be stored for longer than expected (more than 15 days) at a port facility due to shortages of trucks or warehouse space. Additionally, once commodities arrive at a PVOs' primary and secondary warehouses, further delays in distribution may occur, during which insect infestation can result or increase. Once at the local distribution point, food aid is generally quickly distributed to beneficiary communities, where infestation is less likely to occur. Delays in distribution could predispose food aid commodities to infestation and spoilage, especially by insects hatching from stored-products; therefore, fumigation is an important tool to prevent loss.

Most Title II commodities, with the exception of tinned food aid commodities such as vegetable oil, are fumigated with pesticides as they are made ready for shipment from the US, during transit and local storage, or upon arrival in port. As with any program involving post-harvest storage of an agricultural commodity, Title II food aid may become infested with common pests such as weevils, grain borers, flour beetles, mites, moth larvae, mice, and rats. FFP partners and producers, commercial silo managers, handlers, shippers and commodity brokers, therefore, commonly rely on fumigants, contact insecticides, and rodenticides to prevent or minimize the loss of valuable commodity (USAID, 2006).

Given the large scale of USAID Title II programs and questions regarding the use of phosphine gas for fumigation throughout Title II countries, the USAID/DCHA BEO determined that a PEA framework would be useful to provide environmentally sound information applicable to all Title II programs. The framework for the PEA was designed in the USAID 2011 *Scoping Statement for the Programmatic Environmental Assessment for Title II Food Aid Commodity Protection and Fumigation*, which is the primary guidance document for the PEA. The PEA is needed to evaluate alternatives for phosphine fumigation by critically evaluating the knowledge and implementation gaps in best practices, including the safety of fumigation practices for Title II programs. Title II fumigation challenges to address include:

(1) Lack of documentation of best practices for fumigation in host countries.

The issues surrounding food aid fumigation best practices for USG Title II food aid commodities require proper investigation by USAID, other donors, the United Nations (UN) or non-government organizations (NGOs). The UN Food and Agricultural Organization (FAO) produced the Manual of Fumigation for Insect Control for general fumigation of above ground insects, but this manual is significantly outdated (2nd ed. Published in 1969) and does not specifically address Title II food aid or host country considerations (FAO 1984). The existing USAID guidelines detailed in the Commodities Reference Guide (CRG) (http://transition.usaid.gov/our_work/humanitarian_assistance/ffp/crg/sec4.htm) are not detailed enough for practical use under logistically difficult host country conditions. Best practices that are implementable in host-countries need to be identified and methods for accountability (e.g., reporting to the PVO, documenting implementation) need to be established.

(2) Highly variable implementation of pest management best practices due to a lack of tools for fumigators.

Few tools exist for USAID/FFP and Title II partners to ensure fumigation is consistently practiced in accordance with internationally recognized best practices. Different partners are using distinct approaches with varying degrees of sophistication, some of which are not fully effective in ridding the food aid of insect pests, resulting in either multiple fumigations or inedible food. FFP partners have had to destroy many hundreds of metric tons of commodity due to infestation when fumigation was unsuccessful. In addition to preventing food from reaching malnourished and critically food insecure beneficiaries, disposing of large quantities of spoiled or contaminated food aid is an environmental management challenge. Tools for identifying infestations, evaluating fumigation monitoring procedures, and assessing impacts must be developed, as well as documentation standards and reporting requirements for all the fumigation steps.

3) Lack of environmental and human health and safety information for the use of fumigants.

Reliable information on health effects of fumigation on applicators, warehouse workers, nearby residents, and beneficiaries of food aid, as well as the effect of fumigation on the quality of food commodity, is not readily available. Another issue is that some commodities may be exposed to "too many" fumigation cycles because fumigation is ineffective, and therefore, increase the exposure of these individuals to a highly toxic pesticide. Additionally, there are few standards for the treatment and disposal of spent fumigants in an environmentally sound manner. An evaluation of risk to human health and of the potential threat to the environment needs to be developed.

I.2 GOALS OF THE PEA

To complete the knowledge gaps in the use of fumigants in Title II food aid, the PEA will:

- Bring the Public Law (P.L.) 480, Title II program into overall compliance under the precepts of the Agency's environmental regulations;
- Identify the potential for adverse human health and environmental impacts from fumigation of food aid and recommend corresponding mitigation and monitoring measures;
- Develop tools and guidance that will lead to safer fumigation procedures and thus safeguard food aid quality, protect human health, and minimize adverse environmental impacts; and
- Build capacity for best management practices related to food aid protection via integrated pest management (IPM) and fumigation across the full array of stakeholders involved in Title II food aid.



I.3 OVERVIEW OF FUMIGANTS IN FOOD AID

Commodities intended for food aid must meet standards for live stored-product insects. To ensure that the US government is not liable for any losses due to insect infestations and to minimize food wastage, food aid commodities, with the exception of vegetable oil, are fumigated with aluminum phosphide prior to shipment. Fumigation may occur at various points in the commodity procurement supply chain, such as in a grain silo on the farm or at an elevator, truck, rail car, container, warehouse, distribution center, processing facility, port, or in the vessel hold.

Typically, USAID food aid may become infested with various stored-product insect species in the vessel, upon arrival at the destination port, or when stored at the primary, secondary, or tertiary warehouses (distribution points). Food aid commodities have a shelf life of one year or less, and during the time they are in storage, PVOs must preserve the integrity and safety of the commodity. Prevention of spoilage of food requires proper storage, transportation, handling, and pest management practices.

Fumigations performed in the US are required to be conducted by trained and certified applicators following proper safety precautions, which include developing a fumigation management plan (FMP) [see FMP template in Annex T-3]; using proper personal protective equipment (PPE) that is well-maintained; monitoring phosphine gas during and after a fumigation; notifying proper authorities (fire and police) and bystanders that a fumigation is taking place; and clearance of fumigant from the treated space with or without the aid of fans. Applicator standards and fumigation practices in Title II recipient countries are highly variable. In most cases the applicator training and fumigation practices in recipient countries do not meet the stringent US requirements, and the fumigation process may not be compliant with the product labeling.

I.4 OVERVIEW OF REPORTING REQUIREMENTS PER USAID ENVIRONMENTAL REGULATIONS

USAID's environmental regulations per Title 22, Code of Federal Regulations (CFR), Part 216 (http://transition.usaid.gov/our_work/environment/compliance/22cfr216.htm), commonly referred to as Reg. 216, establish the conditions and procedures for the environmental review of activities funded with USAID resources. According to the Pesticide Procedures outlined in 22 CFR 216.3(b), all Title II PVOs who provide assistance for the procurement or use of pesticides, including fumigants, must produce an Initial Environmental Examination (IEE), including an evaluation of user hazard in a 12 factors analysis, aka the Pesticide Evaluation Report and Safe Use Action Plan (PERSUAP). These documents include an evaluation of the economic, social, and environmental risks and benefits of the planned pesticide use. However, concerns have emerged in recent years about whether the environmental documentation submitted by PVOs as part of their Title II requirements (i.e., an IEE and a PERSUAP) is adequately rigorous to fully ensure that the appropriate environmental management measures are being taken for fumigants and that the program operates in an environmentally sound manner as required by USAID's regulations.

Further, in accordance with 22 CFR 216.3(b)(1)(ii), when a project includes assistance for the procurement and/or use of pesticides registered for the same or similar uses by the U.S. Environmental Protection Agency (USEPA) and the proposed use is restricted by the USEPA as a Restricted Use Pesticide (RUP) on the basis of user hazard, a full EA (or Programmatic EA [PEA] such as this one) must be developed. According to the USEPA, all aluminum phosphide and magnesium phosphide fumigant products are classified as RUP based on the criteria "Human Inhalation Hazard." Therefore, in accordance with USAID's Pesticide Procedures, the "procurement or use" of aluminum phosphide or magnesium phosphide fumigants in USAID Title II programs requires an EA and an evaluation of user hazard. In addition, USAID may provide technical assistance to address any risks associated with the use of RUPs. The PEA differs from the EA in that it applies broadly to multiple programs where uses and environmental contexts are similar, as in this case with Title II food aid programs. The PEA must include an evaluation of the user hazards associated with the proposed USEPA restricted uses to ensure that implementation includes mitigation of the risks. This PEA

addresses and further resolves these concerns.

I.5 APPLICATION OF THE PEA FOR PARTNER PROGRAMS

This PEA (and the more detailed HHRE) is **intended to satisfy the Reg. 216 requirement for an evaluation of user hazard**. Approval of the PEA by the DCHA BEO for use in partner programs is dependent on:

- 1) The programmatic nature of Title II activities, and
- 2) The evaluation of user hazard contained in Section 5 #1-4 as well as the full HHRE in Annex K.

This PEA does not preclude the need for Title II PVOs to prepare PERSUAPs for their programs that provide assistance for the procurement or use of aluminum or magnesium phosphide. Rather, it provides information and tools that can be used when preparing country or PVO partner-specific PERSUAPs (see Annex T-2 for an annotated template of a PERSUAP for aluminum phosphide). As stated above, the user hazard evaluation contained herein applies to all Title II PVO programs. The tools (Annexes T-2, 3, 4, 7, and 9) can easily be used and revised, as needed, for country and partner-specific situations, and thereby, can provide mitigation for proposed aluminum and magnesium phosphide use as described and requested in PVO PERSUAPs.

I.6 METHODOLOGY OF THE PEA

I.6.1 SCOPING STATEMENT

As required by 22 CFR 216.3(a)(4), the *Scoping Statement for the Programmatic Environmental Assessment for Title II Food Aid Commodity Protection and Fumigation* was prepared to guide this PEA (USAID, 2011). Excerpts are provided in Annex C. The Scoping Statement reviewed the current activities associated with the protection and management of food aid commodities from procurement to distribution, with particular attention to fumigation practices. It describes the P.L. 480 Title II food aid program, concerns regarding infestation of Title II food aid commodities, including the main pests and the need for pest management, including fumigation; lists the key stakeholders; and identified the potential adverse environmental impacts. Additionally, issues excluded from further analysis and identification of alternatives to fumigation were identified as necessary to address in the PEA.

The Scoping Statement was developed in a participatory manner through questionnaires to the USAID missions with Title II programs and consultations with the Food Aid Consultative Group (FACG). The FACG was created as part of the U.S. Farm Bill in 1990. The intention of the group is to “review and address issues concerning the effectiveness of the regulations and procedures that govern food assistance programs established and implemented...under PL 480.” Therefore, the group was selected as critical stakeholders to direct the PEA. In addition, the FFP Environmental Working Group (EWG), which includes PVOs environmental specialists, reviewed and provided comments on the Scoping Statement. Based on input from these stakeholders, the Scoping Statement was finalized in July 2011; it was widely disseminated among Title II stakeholders.

I.6.2 PEA METHODOLOGY AND STRUCTURE

The PEA evolved from the Scoping Statement, in which three components were identified as necessary to meeting the needs of the PEA. The three main components are:

- 1) **Stakeholder Consultations**

The PEA process was largely informed by stakeholder consultations in the US and USAID partner countries. Extensive stakeholder consultations were conducted in Washington DC prior to field visits. These planning sessions included stakeholders throughout the food aid commodity chain, from procurement of food to distribution to beneficiaries. Stakeholders included PVO headquarters' staff, the World Food Program (WFP), transporters, fumigation consultants, commodity suppliers, and logistics experts. The Washington DC engagements provided focus in framing the questions for the field visits, site selection, and PVO in-country coordination; the engagements also provided stakeholders a forum for voicing their organizations concerns and questions.

2) Field Work

During field visits to Uganda, Ethiopia, and Djibouti, the PEA Team met with USAID Missions in each country, PVOs, fumigation service providers, port authorities (Djibouti), warehouse managers (pre-positioning warehouse in Djibouti), and transporters and surveyors of Title II food aid to discuss processes, logistics, contracting, and specifics of each supply chain.

3) Human Health Risk Evaluation

A concern raised during the Scoping process for the PEA was whether dangerous residues of the fumigant could remain on food aid destined to be consumed by project beneficiaries. Therefore, the PEA process included the Human Health Risk Evaluator prepared a Human Health Risk Evaluation (HHRE) to assess the risk to beneficiary consumers, fumigation applicators, warehouse workers, and nearby residents due to use of the fumigant, phosphine gas (hydrogen phosphide), at warehouses where USAID FFP food aid commodities were being stored. The HHRE provides semi-quantitative and qualitative estimations of potential risk to human health that may result from phosphine fumigation practices. The PEA used the HHRE as a basis for identifying potential impacts to the health of fumigators, other on-site warehouse workers, warehouse visitors, and to beneficiaries.



Checking for insects with Bug Lamps at a food storage warehouse

From stakeholder consultations, fieldwork, and HHRE this PEA evaluates the proposed actions (i.e., phosphine fumigation), recommends and evaluates alternatives, revises the alternatives proposed in the Scoping Statement. Section 3 provides a description of the proposed alternatives and the environmental impacts of those proposed actions. Section 4 discusses the affected environment for those alternatives, and Section 5 provides the analytic basis for the comparison of alternatives. A toolkit developed as a resource for partners is provided in Annex T.

KEY PERSONNEL

The selection of key personnel for the PEA Team was identified as a critical factor to the success of the PEA in the Scoping Assessment. The PEA Team was integrated into all aspects of the stakeholder assessments, desk studies, and field work. Each team member was selected based on their expertise in the subject area (i.e., fumigation/food specialist, social and gender impact, and human health risk evaluation). A short description of their duties is provided below and in Annex C. The final PEA Team composition consisted of the following specialists (biographical sketches of team members are included as Annex D):

- **Team Leader/Environmental Review Specialist**

As the overall team lead, the Team Leader was responsible for oversight of the design and implementation of the PEA activities, acted as lead author for the PEA, and was responsible for editing and compilation of the PEA report. The Team Leader also managed interactions and communications with USAID/FFP, USAID Missions, and PVOs.

- **Food Grain Protection and Fumigation (FGPF)/IPM Specialist**

The Food Grain and Fumigation (FGPF)/IPM Specialist was required to have internationally-recognized expertise with extensive real exposure and involvement in fumigating food aid commodities in different settings around the world. The FGPF/IPM was responsible for identifying potential adverse environmental and health impacts of the proposed and alternative activities as well as developing mitigation measures and the monitoring plan. The specialist also informed the HHRE on host-country fumigation practices and evaluation of impact of fumigants on commodities.

- **Participatory Stakeholder Analyst (PSA)/NGO Liaison**

The Participatory Stakeholder Analyst (PSA) and NGO Liaison (PSA) was responsible for obtaining stakeholder views on potential social/health and gender impacts and their thoughts and recommendations on how to mitigate (minimize or avoid) those impacts.

- **Social Impact Assessment (SIA) Specialist**

The SIA was responsible for interviewing both community leaders and local stakeholders (staff of the CSs/NGOs and host government agencies) and the beneficiaries themselves about the premises of the food aid programs in which they are involved. The SIA worked directly with the Team Leader and the PSA.

- **Technical Quality Control/Quality Assurance (QA/QC) Specialist**

An expert in pesticides/IPM, and USAID environmental compliance processes including PERSUAPs provided expert for QA/QC review for the PEA planning and final report.

- **Human Health Risk Evaluator**

A critical component to the PEA is the Human Health Risk Evaluation presented in its entirety in Annex K. The Human Health Risk Evaluator was responsible for this desk study, which was also informed by the PEA field visits. The HHRE duties included the compilation of toxicity information on fumigants and their alternatives as well as the evaluation of exposure pathways, determination of key populations at risk, and the review of literature regarding exposure concentrations.

FIELD SITE SELECTION

Field site visits were a critical aspect of the PEA for highlighting the host country issues with logistics and fumigation. The visits tracked food aid from the primary ports. The Scoping Statement recommended that the PEA Team should visit country programs that included both relatively small and well-organized programs and ones that would illustrate some of the more difficult circumstances under which food aid is stored up-country. The Scoping Statement also envisioned visits to two or three pre-positioning warehouse facilities.

The Scoping Statement described field work as consisting of visits to two country programs in Eastern and Southern Sub-Saharan Africa (possibly Kenya and Zimbabwe), from primary warehouses (like Mombasa) to community distribution points. In addition, the Scoping Statement surmised that travel to the port of Jacinto (Houston) might be useful. Finally, if time and resources allowed, the Scoping Statement recommended a visit to the port of Chittagong in Bangladesh and/or to the FFP program in Haiti.

In the final SOW for the PEA (an excerpted version of the SOW is in Annex E), the number of site visits was decreased to two country programs. In consultations with PVOs, FFP, USAID missions, and the PEA Team, Ethiopia and Djibouti were chosen as the locations for site visits. The recommendation for these countries was based on the opportunity to visit stakeholders along the entire Title II food aid chain; to meet with several PVOs (five PVOs are active in Ethiopia); to follow the food aid from distribution point to port; and to visit a port operation with a significant focus on food aid storage and distribution. In addition, because the Participatory Stakeholder Analyst is based in Uganda, she undertook site visits there.

The total LOE was decreased by about 50% from the LOE envisioned in the Scoping Statement; as above, this was primarily because of lack of sufficient funding.

STAKEHOLDER ENGAGEMENT

The PEA process was largely informed by stakeholder consultations in the US and USAID partner countries, namely Uganda, Ethiopia, and Djibouti. USAID FFP offices in these countries provided contact information of, or made appointments on behalf of the PEA Team, with their food aid stakeholders. A detailed list of contacts is provided as Annex F.

The Participatory Stakeholder Analyst (PSA), with assistance from the Social Impact Analyst (SIA Specialist), developed a participatory stakeholder research instrument to inform the consultation process and ensure that interviews were carried out constructively, to achieve maximum outcome. The research instrument document contains a set of questions, specific for each stakeholder group that was consulted. The multi-disciplinary PEA Team ensured that the methods and techniques used in data collection were complementary and that each method verified data collected by another tool or method. For example, by using a combination of telephone or individual in-person interviews, small group discussions, and site visits, the PEA Team could verify, correct, and build onto information previously collected. Additionally, the Team ensured they used more than one reliable source for information gathering; this involved meeting with more than one of the specified stakeholder categories.

As part of the stakeholder research instrument, the PSA and the SIA Specialist conducted a stakeholder analysis along the USAID food aid supply chain to best determine which groups of affected and otherwise

interested parties should be consulted during the PEA process, especially as relates to fumigation practices and potential impacts. The PEA Scoping Statement also recommended stakeholders to be consulted during the PEA. Based on the stakeholder analysis and taking the Scoping Statement recommendations into consideration, the PSA and SIA Specialist identified the following groups of stakeholders to target during the PEA process:

- PVOs, FFP Officers and FFP staff
- Fumigation staff and fumigation company representatives (managers)
- Warehouse workers
- Beneficiary communities
- Transportation companies representatives and workers
- Port Authorities (private or government)
- Surveyors
- Fumigation training and certification companies
- Residents in close proximity to the storage sites where fumigation is normally carried out

The PSA and SIA Specialist selected these groups of stakeholders based on:

- Those involved in the development of food aid programs and who also have considerable influence on the entire supply chain from procurement to the distribution of food aid. This group also makes decisions on the types of food protection techniques applied along the chain, i.e., fumigation.
- Workers, including supervisors at food commodity storage facilities (primary and secondary warehouses) and distribution centers at the community level
- Those directly involved in application/use of fumigants, including the supervisors
- Those involved in transporting food commodity
- Companies providing fumigation services
- Companies that train personnel involved in application of fumigants
- Those involved in certifying fumigation companies
- Those who come into direct contact with fumigated food commodities, i.e., workers and managers at storage facilities and silos
- Food aid recipients/communities (to test the social hypothesis of whether they are satisfied with the quality and safety of food aid)

The PSA and SIA Specialist identified fumigation issues relevant to the above stakeholders (Table 1). Based on these issues, the PEA Team (Team Leader, PSA, and FGPF Specialist) then developed research questions specific to the different stakeholder groups (see Annex G). Responses to these questions have informed much of the PEA.

Table 1 describes the roles the stakeholders play and the impacts they have on the fumigation process. These roles (or dimensions) are described as “power” (making the decisions), “support” (carrying them out), and “need” (beneficiary recipients of the food aid). These differences are important when one considers impacts because stakeholders in these different categories are affected differently. For example, the FFP officers in USAID would be stakeholders with “power.” The fumigation workers are “support” – they carry out the instructions from those with power. And the beneficiaries have “need” – they simply receive the product supplied to them. Those with “power” often experience very little impact, but their decisions can increase or decrease harmful impacts on the other stakeholders.

TABLE 1: STAKEHOLDER CATEGORIES AND ROLES AND EXAMPLES OF FUMIGATION ISSUES RELEVANT TO EACH GROUP

STAKEHOLDER CATEGORY	ROLE/ DIMENSION (POWER/ SUPPORT/NEED)	RELEVANT ISSUES (EXAMPLES)
USAID, Recipient Country government, Port Authorities	Power	Monitoring and supervision; ensure application of food aid commodity guidelines; protection of US and recipient country reputation
FFP Officers	Power/Support	
Cooperating Sponsors Involved in: Monetization through commercial suppliers Distribution to beneficiaries	Power/Support	Choice of fumigation program and products; ensuring fumigation compliance through reputable pesticide companies; monitoring fumigation; ensuring food commodity protection and safety; food commodity clearance at the port
Fumigation company representatives; Fumigation training and certification company Fumigant applicant workers	Power/Support Support	Certification to authorize practice; experience and reliability; application products, methods, schedules for fumigation; human resources processes: selection, training, occupational health and safety procedures, supervision, and reliability
Commercial buyers/Suppliers	Support/Need	Compliance with fumigation/food commodity protection regulations; quality of storage facilities
Shippers to-country Truckers in-country	Support	Attempt to protect food commodity en-route; containers, holds sealed against infestations and rodents; application of food commodity protection procedures, e.g. fumigation on board/in-transit?
Community beneficiaries	Need	Perceived quality/equity of supply; protection of product during travel to collect supply and storage thereafter- any food commodity protection training offered? Any feedback mechanism in place if commodity is infested or deteriorated?
Affected communities Community or School leaders Near-storage facility populations	Need/Support	Safety and protection of product en route; cleanliness and safety of distribution centers at the community level; responsibilities/competence to store and protect food commodity; maintain and ensure quality of supply; safety of the fumigated bags for staff and children; any human health impacts of fumigation or potential for re-infestation?
All	Any	Stakeholder relationship issues that impact food quality and protection, e.g., lack of communication; distrust; poor or dishonest practices; lack of training and capacity; lack of transparency; ethics; disturbances because of perceived unfairness by beneficiaries in distribution procedures, etc.

In discussions with USAID FFP Officers and PVOs, the PEA Team recognized it was important to explain the purpose of the PEA in a manner that would not raise alarm among stakeholders. To this end, the PEA Team decided that residents living on-site or nearby the storage facilities would not be consulted. The

warehouses visited in Uganda, Ethiopia, and Djibouti were not located near residential areas. In addition, the PEA Team did not manage to meet with companies that train and certify personnel in fumigation. However, questions relating to training on fumigation, certification, refresher courses, including institutions that offered these, were posed to, and discussed with select stakeholders, namely PVOs and fumigation companies.

I.6.4 INTERVIEWS WITH COOPERATING SPONSORS, STAKEHOLDERS, AND FOOD AID COMMODITY SPECIALISTS PRIOR TO SITE VISITS

The PEA began with stakeholder consultations in Washington, D.C. on January 25 and 26, 2012. The PEA Team Leader represented the PEA Team at these information gathering sessions, and the USAID/DCHA BEO and DCHA Post-Crisis Environmental Advisor attended each meeting.

For the information gathering sessions with Title II PVOs and USAID staff, the PEA Team Leader used the questionnaire developed during the scoping process, as revised for the PEA phase (The stakeholder research instrument had not yet been prepared.) A list of those interviewed during these sessions is included in the List of Contacts in Annex F.

Key objectives of the Washington, D.C.-based PEA consultations were to identify:

- Government, private sector, and PVO players involved in the food aid commodity chain;
- Roles and responsibilities for fumigation of Title II commodities;
- Additional concerns regarding fumigation not already identified during the scoping exercise;
- Contacts in the US and field that should be interviewed for the PEA; and
- Recommendations for PEA fieldwork locations.

The PEA Team Leader held remote interviews with food aid specialists and other stakeholders who had expressed interest in the PEA yet were unable to attend the Washington, DC-based PEA consultations. The questionnaire used during the Washington, DC consultations, revised as applicable, was also used for remote interviews. Those interviewed remotely are listed in Annex F.

The USAID/DCHA Post-Conflict Environmental Advisor presented the PEA framework and initial findings of the PEA exercise at the International Food Aid Development Conference (IFADC) Special USAID and USDA Workshop in Kansas City in May 2012. The objective of the talk presentation was to inform PVOs on the preliminary results of the PEA and solicit feedback and additional participation. Follow-up questions from the audience included the implication of the PEA on environmental reporting requirements to USAID, the use of alternatives to aluminum phosphide, and interest in guidance for overseas fumigators.

I.6.5 LITERATURE REVIEW AND DESK STUDY

The PEA phase built on the literature review that was started during the scoping phase. During scoping, documents related to the protection and fumigation of food aid commodities were identified and compiled. To ensure this literature was accessible to the PEA Team and to stakeholders, a “Community of Practice” on SharePoint was established. As stated in the Scoping Statement, the intention is to eventually share this site with a wider stakeholder audience.

Documents currently available at the SharePoint site provide a great range of information on fumigation of Title II food aid and related topics. Documents range from highly technical to basic information for laypeople, and include USAID, WFP, and PVO guidelines for fumigation, documents produced as part of the scoping and PEA process, research papers on such topics as sorption/desorption and packaging of food aid commodity, and other areas of interest to Title II PVOs and FFP.

A literature review on the current knowledge for fumigation impacts, alternatives, and mitigation measures and a cross-sectoral review on the social and gender interactions with alternatives and mitigation measures were produced as part of the PEA. A short description of the reviews is provided below.

1. The Fumigation Review is a state of the art literature review consisting of a summary of key fumigation impacts, such as potential adverse health and environmental impacts; possible mitigation measures; a summary of fumigation and IPM alternatives identified from the literature; and recommendations for areas of team focus for the PEA site visits.
2. The PSA literature review on (a) the most current and appropriate literature on potential social/health and gender impacts and mitigation and monitoring measures related to food aid protection and fumigation, especially for fumigation workers and fumigation company staff, but extending to warehouse workers and, to a more limited extent, beneficiary communities; and (b) traditional methods of protection against pests of stored food (See Annex I).

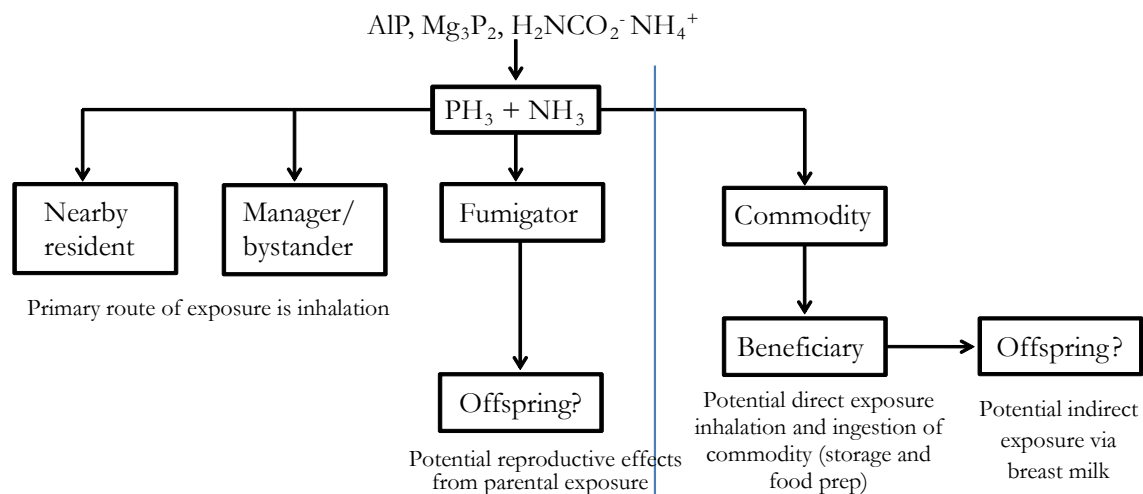
I.6.6 HUMAN HEALTH RISK EVALUATION

The HHRE was included as part of the PEA because data gaps exist that prohibit site-specific quantitative risk estimates for receptor populations exposed to fumigants in Title II food aid commodities. The potential risk of fumigant use to key populations was also a critical factor into the assessment of the proposed action and evaluation of alternatives. Therefore, a separate report, prepared simultaneously with the PEA, was included in the final PEA design. *The Screening Human Health Risk Evaluation (HHRE) on the Use of the Fumigant Phosphine Gas and its Primary Precursor Aluminum Phosphide* was commissioned as a desk study, to be informed by site-specific details garnered from the field visits. The findings were fed into draft and final PEA results, recommendations, and guidance presented herein. The detailed HHRE is provided in Annex K.

The draft HHRE was based on the available data from guidances, peer-reviewed literature, as well as expert opinion, to conservatively estimate threshold exposure limits to beneficiary consumers. In the absence of complete exposure pathways, toxicity data, or exposure point concentrations, risk was qualitatively evaluated. Upon collection of data from the field visits, relevant information was used to revise the HHRE, and the conceptual site model for the HHRE was developed (Figure 1.1). The conceptual site model summarizes the primary routes of exposure and populations potentially at risk.

The focus of the HHRE was to assess the risk to beneficiary consumers, fumigation applicators, warehouse workers, and nearby residents due to the use of phosphine gas as a fumigant to protect food aid commodities for USAID FFP international humanitarian assistance programs. The HHRE provides quantitative and qualitative estimations of potential risk to human health that may result from phosphine fumigation practices.

Figure 1.1. Conceptual Site Model for Fumigants in Food Aid



Exposure information for the HHRE was obtained through observations and interviews with fumigation personnel at sites where USAID-distributed commodities are fumigated. This exposure information was used in conjunction with an example data set from USEPA from a tobacco warehouse to illustrate the potential risk associated with the inhalation of phosphine gas to fumigators and managers/bystanders during fumigation operations. Residents that may live in close proximity to fumigation sites are discussed qualitatively.

As the HHRE states, Risk Characterizations are typically supported by field data that can be used to reliably estimate the concentrations of a chemical or chemicals that are present during human exposure scenarios. However, for the HHRE of phosphine fumigation, site-specific field data on phosphine concentrations were not collected or available. In light of this, other information and data sources were substituted, including anecdotal information, interviews, literature, and air monitoring data from the USEPA Reregistration Eligibility Decision (RED) document for aluminum and magnesium phosphide (USEPA, 1998).

The PEA Team worked closely with the HHRE Team to obtain information the HHRE Team needed to complete their analyses. To that end, the PEA Team included questions in the stakeholder research instrument that would ensure HHRE-requested data were gathered during fieldwork in Uganda, Ethiopia, and Djibouti. The PEA Team has incorporated HHRE results into the PEA; in particular, the PEA draws heavily on the HHRE for the analyses in the Environmental Consequences section (Section 5), issues #1 to #4.

I.6.7 FIELDWORK

TEAM LEADER STUDY TOUR TO MANHATTAN, KANSAS

In January 2012, the PEA Team Leader traveled to Manhattan, Kansas, home of Kansas State University, and where Professor Bhadriraju Subramanyam (Subi), the FGPF/IPM Specialist, is based. They visited the grain sciences laboratory, where they looked at various degrees of grain infestation; a grain silo as it was being prepared for a fumigation; and Central States Enterprises in Salina, Kansas, to get firsthand experience of fumigation company operations and fumigation practices in the US, including various methods of fumigant monitoring and personal protective equipment (PPE).

PSA FIELDWORK IN UGANDA

In early April 2012, prior to the site visits in Ethiopia and Djibouti, the PSA held the following meetings in Kampala, Uganda:

- A briefing session with the USAID/Uganda Mission: The purpose of this meeting was to ensure that there was a common understanding for both USAID and their PVOs, of the PEA process and what it intends to achieve.
- Small group discussions with two USAID PVOs, Mercy Corps and ACDI/VOCA: These discussions were aimed at gaining insight into their food aid supply chain and food commodity protection methods and practices, especially with regard to the use of fumigants.
- A tour of the ACDI/VOCA warehouse: The PSA visited the warehouse to see how food commodity is stored and to obtain firsthand information on their fumigation schedule.
- An interview with the Operations Manager of Supreme Fumigation Services Ltd: The aim of the meeting was to gain an understanding of the company's fumigation practices.

PEA TEAM'S FIELDWORK IN ETHIOPIA

The Team Leader, PSA, and FGPF Specialist met, as a team, for the first time in Addis Ababa, Ethiopia. There, they reviewed and revised the draft participatory stakeholder research instrument developed by the PSA and the SIA Specialist; revised the alternatives to be analyzed in the PEA; and revised the list of potentially significant impacts to be analyzed in the PEA and provided justification for eliminating potential impacts from further study.

The PEA Team held a briefing for the USAID/Ethiopia Mission to discuss fieldwork plans, PEA methodology, including opportunities for USAID input to the PEA, and expected outcomes of the PEA. Prior to conducting site visits, the PEA Team met with USAID/Ethiopia Title II PVOs to discuss the PEA process and interview methodology, and to finalize fieldtrip plans.

The PEA Team visited warehouses in Adama (Nazareth) managed by Save the Children (Save), Catholic Relief Service (CRS), and World Food Program (WFP). The site visits aimed at learning about warehouse operations including sanitation, commodity management, and pest control, including fumigation and IPM measures. The FGPF Specialist conducted warehouse inspections during these visits. The Team toured storage units where fumigation supplies (PPE, sandbags, and tarps) are kept and a WFP pesticide storage unit (container converted to a storage shed). They also met with representatives of a community that receives Title II food aid.

Upon the Team's return to Addis Ababa, the PEA Team met with commodity transport companies. These transport companies provide trucks to transport commodity from Djibouti (the port and the pre-positioning warehouse or "pre-po" warehouse) to primary warehouses in Ethiopia. The Team also met with pest management companies that provide fumigation services for USAID/Ethiopia PVOs.

The PEA Team de-briefed the PVOs; this included a short information session on best practices in warehouse management, including sanitation, and fumigation. The PEA Team also provided a de-brief to USAID/Ethiopia on the initial findings of the fieldwork.

PEA TEAM'S FIELDWORK IN DJIBOUTI

The PEA Team followed the food aid backwards, from Ethiopia (the beneficiaries) to Djibouti, the port of arrival in east Africa. In Djibouti, site visits focused on the port, and included the pre-positioning warehouse and other commodity storehouses at the port. The Team held meetings with warehouse management companies, food commodity surveyors, and a pest control company that performs fumigations at commodity warehouses. The PEA Team toured the port operations and visited the commodity bagging facility.

From the individual site visits and interviews with Ethiopia- and Djibouti-based stakeholders, the PEA Team identified key information and lessons that can be applied to Title II on a global basis.

2. BACKGROUND INFORMATION

2.1. USAID FFP TITLE II FOOD AID PROGRAM



The United States (US) is committed to the promotion of global food security through its international food assistance and other foreign assistance programs. USAID's Bureau for Democracy, Conflict and Humanitarian Assistance/Food for Peace (USAID/DCHA/FFP) contributes to this commitment by working to minimize hunger in the world so that people everywhere can enjoy active and productive lives and, ultimately, to ensure that one day no one needs food aid. USAID's FFP Program works for a world free of hunger and poverty, where people live in dignity, peace, and security.

The FFP office, through funding provided by the 2008 Farm Bill, 207(f) Oversight Authority under the Food for Peace Act, P.L. 480, Title II, makes agricultural commodity donations to Cooperating Sponsors (PVOs or NGOs, cooperatives, and public international organization agencies, i.e., the UN's World Food Program, WFP) to address food security in development and emergency food assistance programs.

USAID and the State Department submit an annual budget to Congress, which reviews the budget request, determines the level of funding, and approves appropriations bills. Thereafter, FFP establishes annual guidance (posted online) for development and emergency proposals. Once a Title II program is approved, PVOs or IOs order ("call forward") commodities. On behalf of USAID, USDA procures requested commodities listed on "call forwards," evaluates commodity bids, and awards commodity contracts. Working closely with USAID, PVOs or IOs arrange the shipping of commodities from the U.S. port to the recipient country.

In fiscal year (FY) 2010, the U.S. provided more than \$1.9 billion of food assistance to developing countries (approximately 2.1 million metric tons under FFP Title II), which reached over 55 million people in 46 countries (U.S. International Food Assistance Report, 2010). In FY 2011, FFP provided approximately 1.4 million metric tons of Title II food aid as part of programs valued at approximately \$1.6 billion in 48 countries.

Title II food aid is used in a variety of ways, but always for the people most vulnerable to the effects of hunger: children under age five, pregnant women, the elderly, and the poorest families in a community. During a food emergency¹ in which people face imminent food insecurity, food—wheat, sorghum, corn, and

¹A food emergency does not automatically constitute "emergency circumstances" under 22 CFR 216. Reg. 216 exempts projects, programs, and activities from the Environmental Procedures if they are carried out under international disaster assistance, emergency circumstances, or circumstances involving exceptional foreign policy sensitivities. To be exempt, a formal written determination including the justification for an exemption must be made by the Assistance Administrator having responsibility for the program, project, or activity or by the Administrator where authority to approve financing has been reserved by the Administrator.

other commodities—is distributed to save lives. If the symptoms of extreme malnutrition have already appeared, a nutritionally fortified ration with blended, fortified, and processed food is provided. In less dire circumstances, food can be used to compensate people for work, such as building roads or repairing water and irrigation systems. In turn, these projects help protect communities from future hunger by providing a consistent food supply and providing them access to local markets for their produce, preventing chronic malnutrition, and improving their harvests.

Food aid programs may also support:

- Improving in-country agricultural production (linking agricultural producers with American “know-how”)
- Improving women's education about nutrition, resulting in healthier babies and children
- Encouraging the production of higher value commodities that could earn money in local markets
- Providing micronutrients, such as vitamin A, iodine, zinc, and iron, that hungry children often lack
- Feeding children at school to encourage attendance and improve academic performance

The USAID Commodity Reference Guide (CRG: (http://www.usaid.gov/our_work/humanitarian_assistance/ffp/crg/sec2.htm) lists a total of 27 commodities that are distributed in food aid programs to countries in the Africa, Asia, Middle East, and Latin America, and Caribbean regions. The types of food and the food aid programs vary by region and country.

Food aid commodities include 13 whole commodities and 13 processed commodities (plus fortified refined vegetable oil). The CRG has links to various USDA sites that provide information on the standards for food-aid commodities, including processed commodities that are distributed either in bulk or in 25 to 50 kg bags made of multi-walled paper or polypropylene (http://pdf.usaid.gov/pdf_docs/PNACK393.pdf). The commodity fact sheets provide information on the purchased commodity characteristics, such as nutritional value, components in processed fortified or blended foods and their percentages, desired packaging, and minimum shelf life, which in most cases is one year. All of the whole cereal grains and legumes purchased for food aid must comply with the United States Department of Agriculture (USDA) Federal Grain Inspection Standards (FGIS) for human consumption.

A LIST OF FOOD AID COMMODITIES THAT MAY BE DISTRIBUTED AS FOOD AID

- | | | |
|------------------------------|---------------------------------|--------------------------|
| • beans | • emergency food products | • soy-fortified cornmeal |
| • bulgur | • lentils | • soybeans |
| • corn | • peas | • textured soy protein |
| • corn soy blend | • ready-to-use therapeutic food | • vegetable oil |
| • cornmeal | • rice | • wheat |
| • crude degummed soybean oil | • sorghum | • wheat flour |

The “Bellmon Amendment” of 1977 to section 401.b of P.L. 480 states that no agricultural commodity shall be made available under Sec. 403 of the Food for Peace Act unless adequate storage facilities are available in the recipient country at the time of export of the commodities to prevent the spoilage or waste of the commodity, and that distribution of the commodity in the recipient country will not result in substantial disincentive or interference with domestic production or marketing in that country. The USAID BEST

Project has conducted 13 independent market analyses to ensure that these requirements are met. (Studies can be found at http://www.usaid.gov/our_work/humanitarian_assistance/ffp/bellmonana.html.)

In addition, to complement USAID's in-kind food aid, in 2010 USAID started the Emergency Food Security Program (EFSP). EFSP is a cash-based program used primarily when U.S.-purchased, in-kind food aid cannot arrive fast enough to respond to an emergency or when other interventions may be more appropriate than U.S. in-kind food aid due to local market conditions. In FY 2012, EFSP benefitted over 10.7 million* food insecure people worldwide through a variety of emergency food assistance interventions, including:

- Local and Regional Procurement (LRP) - Food commodities purchased within the country where the food is to be distributed or from a nearby country
- Cash Transfers - Cash provided to beneficiaries to be used to purchase essential food and non-food items for their food security
- Food Vouchers - A voucher for specific essential food items or a set cash amount which beneficiaries use at participating local market vendors

<http://www.usaid.gov/what-we-do/agriculture-and-food-security/food-assistance/quick-facts/fiscal-year-2012-emergency-food>

2.2 USAID TITLE II FOOD AID VALUE CHAIN

As mentioned, the USAID FFP office makes agricultural commodity donations to PVOs, who are involved in development and food relief programs globally. To this end, USDA works with USAID/DCHA/FFP to determine the amounts that will be procured for international food aid commodity distribution, out of the available commodity stocks or projections thereof. Procurement of food aid commodities is further programmed to coincide with the food preferences and/or past food aid programs of the recipient countries, which leads to the overall annual procurement list.

USAID provides a list to PVOs of eligible US agricultural commodities, including processed and value-added products. PVOs can then choose from this list, and based on their local assessments of markets and needs, PVOs identify the types and amounts of commodities required and a schedule for delivery. In some cases, on their website, the USDA's Foreign Agricultural Service (FAS) solicits requests for food aid.

USDA's Kansas City Commodity Office (KCCO) of the Farm Service Agency (FSA) solicits bids for specific commodities being procured for aid distribution. The KCCO is responsible for buying the types and amounts of commodities identified on PVO's call forward. Commodities may be furnished from the inventory of USDA's Commodity Credit Corporation (CCC) acquired under price support programs or purchased from private stocks.

USDA procures the requested commodities by issuing a tender to commodity suppliers and processors. USDA evaluates the commodity bids and picks the one(s) that would result in the lowest landed cost based on a combination of the cost of the commodity and the cost of shipping it to the destination country. USDA awards the commodity contract, which identifies the dates that the commodities must arrive at a US port and be ready for shipping. The PVO, through a tender process, arranges for the cargo to be shipped from the US port to the recipient country. Once the PVO acquires ownership of the commodity, it is responsible for handling and management of the commodity, including storage and distribution of the food aid to beneficiaries in accordance with its agreement with USAID.

Whole commodities within the US may be transported, by truck or railcar, directly to port and shipped as bulk commodity; or they are shipped from the farm to processing facilities to make processed foods such as flour or various fortified blends. Flour is usually bagged in polypropylene bags to prevent condensation and

spoilage by molds and bacteria, whereas blended products are bagged in multi-walled plastic and paper bags to prevent insect infestations, product contamination, and spoilage. Trucks then transport processed and bagged materials to ports.

Food aid may be shipped overseas from ports on the east coast, west coast, Great Lakes, and Gulf of Mexico. In FY 2008, about 80.6% of the 2.8 million MT of food aid was shipped from Gulf Coast ports, mainly in Texas and Louisiana (Anonymous, 2010). At ports in the US, food aid commodities are shipped as dry bulk (unprocessed commodities) in vessel holds or as bags (unprocessed and processed) in containers of 6.1 to 12.2 m (20 to 40 feet) long. General cargo shipments may include packaged commodities shipped break bulk in vessel holds or barges. Tanker-type vessels are used for liquids such as vegetable oil. (Vegetable oil is not of concern for infestations, is not fumigated, and therefore, is not included in this PEA.)



ABOVE: USAID provided humanitarian aid in the aftermath of several disasters in 2007, including Cyclone Sidr, which struck Bangladesh Nov. 15. Sue McIntyre. 2007.

Upon reaching its destination, the food is used in a variety of ways. Food aid intended for use in disaster relief, economic development, and other assistance must comply with 22 CFR Part 211 (<http://www.usaid.gov/work-usaid/get-grant-or-contract/grant-and-contract-process>). The regulations cover transfer authorization for government and non-governmental PVOs receiving food aid. Delivery by the US to the PVO is regarded as complete if the commodity ordered for shipment is within a tolerance of 5% (2% in the case of quantities over 10,000 metric tons) of the quantity ordered. There is no tolerance with respect to the ocean carrier's responsibility to deliver the entire cargo shipped and the US assumes no obligation for

failure by an ocean carrier to complete delivery to a port of discharge. The PVO must provide assurance to USAID that all necessary arrangements for receiving the commodities have been made, and must assume full responsibility for storage and maintenance of the commodities from time of delivery at port of entry abroad or, when authorized, at other designated points of entry abroad agreed upon between the PVO and USAID.

Prior to shipment, food aid may be fumigated at US port warehouses, in containers, or in in-transit vessels. Only phosphine can be used for in-transit treatment of commodities in vessels (see Annex A for information on fumigation of vessels during transport); stationary commodities can be fumigated with sulfuryl fluoride, methyl bromide, or phosphine. Port or in-transit fumigations are done to kill any live insects in raw commodities or to kill eggs present in processed commodities.

Food aid shipped in vessels is received at designated ports for delivery to various countries (<http://www.worldportsource.com/countries.php>). When it reaches the receiving port, marine surveyors contracted by the PVO inspect the cargo to determine quantities received and their general condition. The fumigation and phytosanitary certificate that was issued when the cargo left the US port is examined. Surveyors may make a recommendation for fumigation of the containerized or bagged commodities at the port or in a warehouse near the port prior to loading of trucks.

After clearance by marine surveyors and customs, bulk dry commodity is unloaded at the port pneumatically and by conveyor belts either to a flat temporary storage or to feeders above bagging lines for continuous bagging in USAID-labeled bags. Torn or damaged bags holding raw commodities are re-bagged at the port. Damage to multi-walled paper bags is repaired by sealing them with tape.

If all the unloaded material cannot be bagged, the remainder of the bulk material is stored in flat storages. If delivery is to occur to a landlocked country, bagged commodity at the ports is loaded onto containers or

trucks and shipped to a primary warehouse. All shipments to secondary, and tertiary (distribution points) warehouses, before reaching beneficiaries, are by trucks (see Annex B for a chart of the commodity supply chain). Some PVOs, such as World Vision (<http://www.worldvision.org>), use a web-based supply chain management (WBSCM) system throughout the commodity supply chain from the US to the final destination to track and document food aid procured and shipped.

Depending on a country's capacity of port facilities, availability of trucks, and the demand for other materials, such as fertilizers and cement, rather than unloading immediately, food aid may remain on the vessel and unloading may be delayed until other commodities have cleared the port. Delays in unloading could predispose commodities to infestation and, especially by insects, and spoilage. The limited supply of trucks may also result in commodities being stored in containers or at a port warehouse, where they may be exposed to insect infestations.

Commodities may become infested if stored for more than 30 days, and fumigation may be necessary. Insect infestations may be severe especially if bags are damaged or torn. Therefore, reducing the time food aid is stored from the time it arrives at the port until it reaches the beneficiaries, maintains the commodity's integrity and quality, may reduce insect incidence, and may reduce the need for pesticides, including fumigants.

2.3 INTRODUCTION TO PHOSPHINE FUMIGATION AND PHOSPHINE CHEMISTRY

2.3.1 PHOSPHINE FUMIGATION

Fumigation is the act of introducing a pesticide into an enclosed space in such a manner that it disperses quickly and acts in a gaseous state on the target organism. Pesticides formulated as fumigants have physical characteristics which cause them to occupy all air spaces within an enclosed area and to penetrate the commodity within these areas. Phosphine is adsorbed into each kernel, killing insects within the kernel, and then desorbs when exposed to air.

Presently, methyl bromide, phosphine, sulfuryl fluoride, and carbon dioxide are the four most commonly used fumigants. Several fumigants used in the past such as hydrogen cyanide, carbon disulfide, ethylene dibromide, and carbon tetrachloride are no longer used because of adverse human health and environmental effects. Under the Montreal Protocol, because of its ozone-depleting effects, methyl bromide was phased out in 2005 in developed countries and will be phased out by 2015 in developing countries. Methyl bromide is currently used in the US for pre-shipment and quarantine treatments. Before the phase-out, it was used for disinfecting empty grain- and food-processing facilities, but not for commodities. Sulfuryl fluoride, a non-ozone depleting fumigant, was registered in 2004 by the USEPA for use as a commodity and structural fumigant. Currently, USEPA is soliciting a second public comment before making a regulatory decision to revoke its food tolerances. Phosphine is the generally accepted alternative to methyl bromide for treatment of commodities. Carbon dioxide is cost-prohibitive and requires special equipment, leaving phosphine as the cost-effective front-line fumigant to control insect pests in the world's grain stocks. Most modern fumigation is done using aluminum phosphide; magnesium phosphide releases phosphine too quickly for optimum fumigator safety.

Various means can be employed to prevent insects from attacking stored products, but once they get into a stored product, few practical solutions, besides aluminum and magnesium phosphide, are available (<http://www.aces.edu/pubs/docs/A/ANR-1154/>). Aluminum and magnesium phosphide may be used to eliminate insect infestations in a variety of commodities, including animal feed and animal feed ingredients, corn, cottonseed, grass seed, millet, oats, peanuts, pecans, popcorn, rye, sorghum, soybeans, triticale, and wheat. They may be used for a variety of processed foods as long as the residue dust does not get in direct

contact with the product. They can be used on some non-food commodities including straw and hay, cotton, feathers, tobacco, dried plants, and flowers, and on seeds. Phosphine fumigants may be used in a variety of structures including grain bins and silos, rail cars, warehouses, and flat storage structures. One of the major advantages of fumigation with phosphine is that insects can be controlled without moving the stored commodity.

The fumigation process starts with the introduction of the fumigant into a space or commodity that has been properly enclosed, placarded, and secured. It ends when aeration has rendered the space or commodity at or below established safe limits specified in the product label. An integral part of the fumigation process is the safe disposal of the spent fumigant, according to label directions, upon the completion of fumigation.

Fumigant application methods differ depending on (i) the fumigant formulation being used, (ii) the site/area being treated, and (iii) the target pest. Aluminum phosphide is available in several forms, including tablets, pellets, granules in a sachet or small, porous bag, ropes, and blankets. Fumigation of infested grain using a solid fumigant product may involve applying tablets/pellets into the grain with a probe, the use of an automatic dispenser at grain elevators, which uniformly applies the fumigant throughout the grain mass as the bin or silo is filled, or placement of tablets on trays or in envelopes which are then placed beneath pallets of commodity enclosed by polythene sheets or tarps. When liquid phosphine (liquefied gas or liquefied gas under pressure), is used as a fumigant, such as in the ECO2FUME® (<http://www.cyttec.com>) formulation, it is introduced into the treated site through approved tubing, where it disperses as a gas for quick distribution throughout the fumigated area. Cylinderized phosphine greatly minimizes worker hazards inherent when using tablets/pellets, but the formulation is not registered in many countries.

Each aluminum phosphide tablet weighs 3 grams and releases 1 gram of gas; pellets weigh 0.6 grams and release 0.2 grams of gas, and sachets weigh 34 grams and release 11 grams of gas. The speed of gas release is faster with pellets, followed by tablets, then sachets in accordance with surface area. At high temperatures, it may be safer to use tablets because they break down slower than pellets. Tablet residues in grain can be avoided by putting tablets in a single layer on trays, suspending trays in the headspace, or placing trays on the grain surface to assure full reaction. An alternative to using tablets is to use phosphine products that are sold as bag chains, belts or blanket formulations; disposal of spent residue is easier to do with these formulations.

While phosphine is very toxic to mammals, its toxicity to insects is more variable, and depends on the concentration of the gas, grain temperature, and exposure time. Its effectiveness differs from one insect species to another, and between each life stage of the insect; the eggs and pupae are usually least susceptible to the effects phosphine. Furthermore, effectiveness is influenced by the development of insect resistance that results from selective breeding of survivors in poorly sealed fumigated structures.



ABOVE: Flour Beetle (*Tribolium castaneum*).

Stored-product insects have developed resistance to different classes of pesticides including fumigants (Subramanyam and Hagstrum, 1996). According to <http://graintechsystems.com/Fumigation.htm>, the gradual (and sometimes rapid) development of insect resistance has forced fumigators to increase the minimum recommended dosages, which in some cases may be as high as 100 ppm for 28 days or 200 ppm for 15 days. However, it is no longer possible to make generalized recommendations for insect management since insect resistance to phosphine can vary widely among countries, regions, and even individual storage situations. In most developing countries, good fumigation practices are not techniques practiced routinely (e.g., maintenance of fumigant concentrations

during the effective period) to that guarantee the mortality of all insect populations. Instead, application of phosphine under leaky storage conditions and shortened fumigation times may allow some insects to survive; the survivors have the greatest tolerance to phosphine. Through this selection mechanism, the most tolerant insects pass on their phosphine resistant genes to their progeny, developing increased insect resistance. In many cases, insect resistance has dramatically reduced the effectiveness of phosphine as a fumigant. This may represent a serious threat to the world's food-stocks of the future if nothing is done to reverse the trend (Subramanyam and Hagstrum, 1996).

As the gas is released from tablets and pellets, the concentration of phosphine increases rapidly in a linear fashion in the fumigated enclosure; then the gas dissipates or decays exponentially; and after clearance, the gas loss becomes semi-logarithmic (Anonymous, 1989). Phosphine gas moves readily through grain from the point of application. The intent of any fumigation is to maintain sufficient concentration of the fumigant for enough time to kill pests. Because of its high vapor pressure (40 mm Hg at -129.4°C), phosphine gas that permeates from the fumigated site dissipates quickly into the atmosphere, where it is degraded by photoreaction with hydroxy radicals. Its half-life in sunlight is five hours. Phosphine leaks quickly through holes in silos or sheeting; therefore impervious containerization is important for effective fumigation. Wind and large temperature changes accelerate phosphine loss. Most phosphine is lost within four days from fumigations in ordinary, unsealed storages.

The minimum exposure periods with phosphine vary with temperature. Fumigation is not recommended at temperatures below 15°C because insects are inactive at these temperatures. Phosphine is usually most effective at temperatures between 20 and 35°C. At temperatures of 25°C or above, the exposure periods should be 7 to 10 days (Anonymous, 1989; van Graver Someren, 2004). Some labels recommend 2 to 3 days of fumigation, but such short fumigations provide ineffective insect control. Insects are killed slowly by phosphine gas. The fumigant must be kept in contact with the insects for at least 7 to 10 days to kill insects in all stages (eggs, larvae, pupae, and adults) of their life cycle. All life stages are typically found in stored grains. Extending fumigation to 7 days or longer allows the tolerant egg stage to develop into the susceptible larval stage and the tolerant pupal stage into the susceptible adult stage. Longer exposures are also effective for controlling insect strains resistant to phosphine. Fumigation in ordinary, unsealed storages will kill some adults and larvae but most eggs and pupae will survive to adulthood and continue the breeding cycle. Fumigation gives no residual protection to stored grain—insects can re-infest the commodity after the phosphine gas concentration has dissipated.

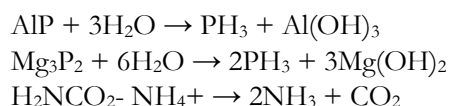
Phosphine is effective against insects in most types of grain. But some commodities (for example, brown rice, paddy rice, legumes, linseed, and cottonseed) soak up (adsorb) phosphine very quickly, leaving little to kill insects (<http://www.aces.edu/pubs/docs/A/ANR-1154/>). Therefore, dosage rates of phosphine vary with the commodity being fumigated. For highly sorptive commodities the dosage may need to be doubled from 3 tablets/metric ton to 6 tablets/metric ton. (See: “The relation between phosphine sorption and terminal gas concentrations in successful fumigation of food commodities.”

<http://www.ncbi.nlm.nih.gov/pubmed/17051623> and Food Protectants and Infestation Control Department, Central Food Technological Research Institute, Mysore 570 020, India.)

After fumigation, the gas must be vented to a legal and safe level for human exposure; in the United States, this level is ≤ 0.3 ppm. This is required regardless of the type of structure; however different types of structures may require different safety considerations or engineering controls (<http://www.aces.edu/pubs/docs/A/ANR-1154/>).

2.3.2. PHOSPHINE CHEMISTRY

Phosphine gas is produced when aluminum or magnesium phosphide formulations react with moisture in ambient air. As phosphine gas is generated through reaction with water that is present in ambient air, ammonium carbamate decomposes to ammonia gas and carbon dioxide gas. The reactions for the generation of phosphine and ammonia are shown in the following equations (Degesch America, Inc., 2010; 2011):



In addition to phosphine, each metallic phosphide produces the corresponding metallic hydroxide (aluminum and magnesium hydroxides, Al(OH)_3 and Mg(OH)_2). The spent hydroxides, depending on the formulation, may contain 0.5-1.0% phosphine gas. After decomposition, phosphide formulations leave a grayish white powder consisting of aluminum hydroxide and other inert ingredients. When exposed properly (i.e., allowed to react for adequate duration and applied at a rate consistent with the volume to be fumigated) the residual materials are considered to be non-hazardous (Degesch America, Inc., 2010; 2011). This spent powder with minute amounts of unspent phosphine must be retrieved for disposal after fumigation, usually buried in the ground away from the fumigated structure or deactivating in a drum containing water and soap. Several other methods for deactivation are given in phosphine product labels.

The inert ingredients in phosphine formulations include ammonium carbamate, ammonium bicarbonate, urea, and paraffin wax, and may include other impurities such as calcium, sodium, and heavy metals (Pan et al., 2005). Some formulations of aluminum and magnesium phosphides contain ammonium carbamate to reduce fire and explosion hazard and as an odoriferous warning agent (USEPA, 2006). Phosphine formulations can be corrosive and can damage equipment if used improperly. Pure phosphine does not have an odor; the odor (most often described as garlic, acetylene, or decaying fish) detected during a phosphine fumigation is due to substituted phosphines and diphosphines (Anonymous, 1999). While the odor can serve as a warning, it is not meant to be used as an indicator of a safe or unsafe work environment, nor does it have an impact on commodities.

3. ALTERNATIVES INCLUDING THE PROPOSED ACTION

The sections below provide a description of the proposed action—fumigation of food aid commodity using aluminum or magnesium phosphide; and of alternatives to fumigation, as identified in the Scoping Statement and revised by the PEA Team. (In some cases in this PEA, aluminum phosphide is discussed rather than both magnesium and aluminum phosphides because aluminum phosphide is far more common in Title II countries. Under warm conditions found in most Title II countries, magnesium phosphide releases gas more quickly than aluminum phosphide, thus increasing risks to fumigation personnel; in cooler weather, magnesium phosphide would be a better choice than aluminum phosphide, but in Title II countries, if magnesium phosphide were to be used, the gas will be released too quickly, while workers are still putting tablets under pallets.)

3.1. DESCRIPTION OF THE PROPOSED ACTION: FUMIGATION OF FOOD AID COMMODITY USING ALUMINUM/MAGNESIUM PHOSPHIDE

This section describes the fumigation process as it is implemented in accordance with international standards and best practices (i.e., in accordance with labeling). Section 1 (Summary) and Section 5 (Environmental Consequences), describe the PEA Team's findings regarding how fumigation is actually practiced in the field and the potential health and environmental impacts resulting from those practices.

3.1.1. ALUMINUM/MAGNESIUM PHOSPHIDE FUMIGATION PROCESS

Decision to fumigate: In the US, fumigation with phosphine is done on a calendar-basis rather than as a result of pest monitoring indicating a need. In Title II situations, a decision to fumigate may be made on a calendar-basis or may be based on the observation of live insects, either in the warehouse or in the commodity (i.e., a threshold should be established, and if in excess of this “infested” category, fumigation would be initiated). Decision making based on the results of pest monitoring avoids repeated treatment of the commodity with phosphine and allows PVOs to use phosphine only when needed (see Annex T-611 for decision-making criteria). 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.

The PEA Team found that at Title II warehouses, a range of decision-making practices is in place. At some, a decision to fumigate is based on observation of insects; some warehouses probe bags to check for insects; and other warehouses automatically fumigate every six weeks to three months. During field visits to Ethiopia and Djibouti, PVOs and fumigation service providers indicated that if live insects are found in the commodity or on the bags and in the warehouse, all of the stacks in that warehouse are treated with phosphine to prevent cross contamination to uninfested stacks.

Preparation of a Fumigation Management Plan: In the US, a Fumigation Management Plan(FMP) for grain in a bin/silo, warehouse, rail car, trucks, or vessels is a label requirement when fumigating with phosphine. An FMP is a written description of the steps designed to plan for a safe, legal and effective fumigation. Site inspection, sealing, notification of emergency responders and bystanders, gas monitoring plans, placarding, and post-application procedures are all part of the FMP(Annex T-3). Some plans are more comprehensive than others. In the US, the certified applicator and owner of the property to be fumigated addresses characterization of the structure and/or area and includes all safety requirements in the plan prior to application. A new FMP is not needed for every fumigation of a facility if conditions will remain the same; only general updates such as temperature and humidity recordings are needed in such cases. The FMP and related documentation, including monitoring records, is maintained for a minimum of two years. See FMP template in Annex T-3.

Fumigation workers: Federal (US) labeling allows trained workers to do certain activities associated with fumigations, but some US states may be more restrictive than others and require that a certified applicator (CA) always be physically present on site (see Annex H). A CA is someone who has passed a state (US) exam and is trained in a particular category such as aerial application or fumigation to use restricted use pesticides. Individuals receiving specific instructions from a CA in documented training sessions are classified as trained applicators. One CA and another trained person are the minimum personnel required when aluminum/magnesium phosphide is applied in the US. Most fumigation activities in the US are carried out by a CA or by a trained worker under the direct supervision of a CA. In some US states, certain activities can be turned over to a trained worker to complete the fumigation independently in the absence of a CA. The CA may remain in voice contact if needed but not physically present (some form of communication device, such as a radio, a walkie-talkie, or a cellular phone is required).

The specific activities that a trained worker may undertake in the absence of a CA are the following (http://www.epa.gov/oppsrrd1/reregistration/alphosphide/fumigation_qa.pdf):

- Monitoring the fumigation site for gas leaks and accumulation of phosphine gas above permissible limits
- Completing the aeration of a structure after the aeration has progressed and stabilized
- Removing placards after the aeration is completed
- Receiving, aerating, and releasing the content of a vehicle fumigated in-transit (in the US, transporting vehicles under fumigation over public roads is prohibited)

- Transferring an unaerated commodity from one in-transit container to another storage site to continue degassing
- Disposal of any spent fumigant
- Maintenance of written records of all permitted actions performed.

Preparing the structure or stack: According to <http://www.aces.edu/pubs/docs/A/ANR-1154/>, the structure or stack must be sealed because:

- If not, the gas will probably leak before it reaches a sufficiently high concentration to kill all the insects, which can lead to spoilage and insect resistance.
- Unsealed or poorly sealed structures are safety hazards.
- Sealing the structure before fumigation is the law (in accordance with the labeling).

Various materials are used to seal structures and stacks, including plastic (1 mm (4-mil-thick) or thicker non-gas permeable), duct tape, expanding foam, and caulk (see Annex T-6 for fumigation tarp specifications). Prior to fumigation, all cracks and crevices are filled and treated with an approved residual contact insecticide prior to loading the commodity into the structure. Sealing quality of the area to be fumigated is determined by a simple pressure (half-life) test (Adler et al., 2000), where a drop from 100 Pa to 50 Pa should be 30 to 180 seconds.

Gas monitoring during fumigation: Respiration rates of insects are much slower than those of humans, especially in cooler temperatures. Only minutes of exposure of a given concentration of phosphine can be very dangerous to humans while the same concentration may take days to kill insects. Monitoring for safety of workers and bystanders is mandatory according to the label (US) and is performed to determine (i) when and where respiratory protection is required, (ii) whether phosphine gas is escaping and is accumulating at unsafe levels in areas other than the treated area, and (iii) to take proper actions to prevent occupational or accidental exposures. Once fumigation has started and gas containment has been adequately characterized, spot checks are made, especially if conditions change significantly (e.g., windy weather) or if an unexpected garlic odor is detected (as mentioned above, garlic odor is not a reliable indicator of leakage) or a change in phosphine concentration outside the fumigation area is detected.

Knowledge of the phosphine gas concentrations during the fumigation process is required as part of compliance with label instructions primarily for protection of workers and bystanders. The (US) label requires that a log be kept showing phosphine gas concentration at key locations surrounding the structure. The type of respiratory equipment used depends on the gas concentration (Annex T-8 provides information on respiratory equipment and other PPE). Furthermore, the gas inside the structure is monitored (using pre-positioned plastic/nylon gas monitoring lines from a safe outside location) to make sure a concentration of gas lethal for insects is present for the duration of the fumigation.

In the US, the CA is responsible for ensuring plans are in place for conducting required safety monitoring during the fumigation period. Trained workers or the CA may perform monitoring (trained individuals may want to verify gas concentration in a railcar are 0.3 ppm or below prior to unloading the cargo, or verify efficacy of grain fumigation underway, etc.). Trained workers must know how to properly use the detection equipment and how to implement site-specific evacuation procedures if necessary.

There are a number of devices on the market for the measurement of phosphine gas. The devices range from glass tubes to electronic and photo ionization equipment. Detection tubes for low and high range concentrations with air sampling pumps, portable devices, and electronic devices may be used to monitor phosphine gas concentration. The average accuracy (percent of time the readings are close to actual concentration) among the available electronic devices ranges from 60 to 100% (Danley et al., 2005). Electronic devices need to be calibrated every four to six months for accurate reading. Tube-type devices are more accurate, but are subject to operator error when reading the tubes. A $\pm 20\%$ accuracy in fumigation

readings during commercial fumigations is acceptable, but a $\pm 5\%$ accuracy is needed for fumigant residue determinations (Anonymous, 1989). Gas monitoring equipment is discussed in detail in Annex T-8.

Monitoring for efficacy involves the placement of gas monitoring lines within the structure/stack and determining whether adequate phosphine gas concentration has been reached. Measurement within the commodity will determine whether lethal concentrations (200-300 ppm) have been held for the duration of exposure (7 to 10 days). Efficacy monitoring will also help to determine whether or not to add more fumigant during fumigation because of poor distribution within the structure/stack or to supplement gas loss due to leakage. This type of monitoring is not a label requirement, but it is typically conducted for effective insect control.

Aeration/Ventilation: The fumigated warehouse and commodity is aired before entering or handling the product to ensure that the phosphine gas levels have dropped to 0.3 ppm or less. If there is a need to enter the structure during ventilation, respiratory protection is used until the air-monitoring equipment indicates that the concentration of phosphine gas is less than 0.3 ppm. Finished foods and feeds that have been fumigated with phosphine are typically aerated for 48 hours before being offered to the end consumer. An alternative is to test the commodity to determine if the phosphine residue is less than 0.1 ppm in animal feed, 0.01 ppm in processed foods, or 0.3 ppm for nonfood items.

Personal Protective Equipment: Cotton or other gloves are worn when handling phosphine tablets and pellets to prevent any gas release and burns from moisture (sweat) on hands. Respiratory protection is important when applying or aerating fumigated structures/sites. A self-contained breathing apparatus or a line with air supply is worn when entering an area where the fumigant concentration is unknown or exceeds 15 ppm or exceeds the short-term exposure limit (STEL) of 1 ppm for 15 minutes. A NIOSH/MSHA approved full-face gas mask is used at levels up to 15 ppm. A full-face canister mask can be worn at concentration of 15.1 to 1,500 ppm only for escape (to remove another affected person from the fumigated area). The approved respirators and concentration limits are given in the NIOSH/MSHA Pocket Guide DHHS (NIOSH) 97-140 or the NIOSH Alert-Preventing Phosphine Poisoning and Explosions. Respirators need to be properly fitted so they are tight to the face and do not allow leaks, and need to be regularly maintained. Evidence to support these worker exposure standards is described in detail by Pepelko et al. (2004). Annex T-8 contains information on the use and maintenance of PPE.

3.2 DESCRIPTION OF ALTERNATIVES TO PHOSPHINE FUMIGATION

Alternatives to the proposed action (*Phosphine Fumigation of Food Aid Commodities*) from the Scoping Statement as revised by the PEA Team are described below, as well as additional alternatives developed during PEA preparation. The alternatives described in this section meet the purpose and need of the project (to control pests in Title II food aid) and are considered practicable. These alternatives will be analyzed in Section 5 against the potentially significant adverse impacts. Alternatives that the PEA Team eliminated, after further analysis, from detailed study in this PEA are described in Section 3.3.


Alternative 1) Use modified and controlled atmospheres: The use of modified and controlled atmosphere treatments for stored commodities has received increasing attention from the scientific community over the last 35 years. Banks (1981), Adler et al. (2000), and Jayas and Jeyamkondan (2002) provide information and assessments on stored-product protection by modified/controlled atmospheres. These alternatives use carbon dioxide (CO₂) or nitrogen (N₂) to replace oxygen (O₂) levels within commodities or structures. They are used to control pest insects, microorganisms, or to maintain product quality. They are a popular form of pest management in organic farming in the US. In a controlled atmosphere treatment, a constant low oxygen atmosphere is maintained at a level lethal for organisms; in a modified atmosphere treatment, the atmospheric composition changes during the treatment period. Controlled atmospheres are used in ECO₂ chambers (see below), where a constant level of CO₂ or N₂ can be maintained. Lethality in low O₂ environments is due to

limited oxygen availability for respiratory metabolism; whereas high carbon dioxide environments inhibit respiratory enzymes and lead to less energy (adenosine triphosphate [ATP]) generation and the accumulation of toxic products (Mitcham et al., 2006).

Modified and controlled atmospheres can be used to treat stored rice, grain, and other bagged and packaged commodities. This alternative can be used for commodities in stacks, stored in sealed bins, or in other enclosures. Stacks, enclosures, and containers must be airtight with a facility to add gas, if needed. Treatment success depends on the quality of the plastic sheeting used, and tightness of the seal between the polythene on the floor and on the stacks. An enclosure treated with carbon dioxide atmospheres should be checked for gas tightness using a pressure test (Banks and Annis, 1980). An applied pressure of 500 Pa (using compressed air or CO₂) should decay to 250 Pa within 5 minutes. For N₂ this half loss time should be 15 minutes (Bailey and Banks, 1975). For effective insect control, atmospheres should have at least 60-95% CO₂ and O₂ levels should be 2% or less. Unlike N₂, CO₂ rich atmospheres also exert a toxic effect due to hypercarbia (Calderon and Navarro, 1979). Insects under these atmospheres open their spiracles (respiratory openings on the exterior of the body), which facilitates their rapid desiccation. Mortality of stored-product insects and mites in low O₂ atmospheres or in high CO₂ atmospheres can take 2 to 56 days depending on the species, insect life stage, temperature, and relative humidity (Bell, 1996; Krishnamurthy et al., 1986; Banks and Fields, 1995) (see Table 2 below).

A Danger Placard in English and Shona for a Phosphine Fumigation Event in Zimbabwe

DANGER/HOKOYO



VERY POISONOUS GAS

DO NOT ENTER/DO NOT OPEN
Commodity Under Fumigation With
PHOSPHINE GAS

STACK/CONTAINER NO. _____ JOB NO. _____


NAME OF FUMIGATOR: _____

FUMIGATION DATE: _____

DO NOT OPEN BEFORE: _____

CONTACT PHONE: 04 612897, 04 612900, 0772 353980

ENTOMON INSECTS, 527 (off) EMPOWERMENT WAY, WILLOWVALE,
P.O. BOX CH 654, CHISIPITE, HARARE.

 IN CASE OF POISONING, SEE REVERSE

A company in Netherlands (ECO2, <http://www.eco2.nl>) developed a controlled atmospheric treatment chamber that creates low O₂ environments by means of an O₂ burner or a N₂ generator, resulting in O₂ levels of less than 2%. The system has the ability to control temperature, gas concentration, and humidity to ensure 100% control of all insect stages of stored-product insects within 3 to 5 days. Chambers of various

sizes can be custom built at warehouses, food-processing facilities, or port terminals to treat palletized products, products on trucks, and products within containers. The systems are available in 14 countries in Latin America, Asia, Africa, the Middle East, and Europe. One thousand to 20,000 metric tons can be treated yearly with the chambers.

The ECO2 chambers are of two types. One is a mobile unit for treating commodities stored in silos, while the other is a permanently installed structure. Both types can be used at port warehouses and primary warehouses. All ECO2 chambers can be leased or purchased. Each permanently installed chamber can hold 52 pallets with bags in two layers or 26 pallets in one layer. If one assumes one treatment per week for one year (52 weeks), a total of 2,704 pallets with bags can be treated. It costs about US\$60 per year or US\$11.2 per pallet per ton to rent the permanent systems—much more expensive than fumigation with phosphine which costs about US\$ 0.59 per ton. If purchased, the system would cost about US\$268,000 with a yearly maintenance cost estimated at US\$10,000.

Efficacy: Mortality of stored-product insects and mites in low O₂ atmospheres or in high carbon dioxide atmospheres can take 2 to 56 days depending on the species, insect life stage, temperature, and relative humidity (Bell, 1996; Krishnamurthy et al., 1986; Banks and Fields, 1995) (see Table 2 below). The recently developed rapid treatment system of ECO2 chambers provides complete insect control within 5 days.

TABLE 2: EXPOSURE TIME IN DAYS REQUIRED TO CONTROL DIFFERENT STORED-PRODUCT INSECTS AND MITES WITH MODIFIED ATMOSPHERES AT DIFFERENT TEMPERATURES (SOURCE: BELL, 1996).

Species and stages	60-95% carbon dioxide			<1% oxygen		
	15°C	20°C	25-30°C	15°C	20°C	25-30°C
Grain mite, all stages ^a	6-10	8-14	— ^b	7	—	—
Rusty grain beetle, adults	7	—	—	10	6	2
Almond moths, eggs and larvae	7	—	—	6	5	2
Cigarette beetle, all stages	—	—	6	—	9	6
Psocids, all stages ^c	10	8-14	—	—	—	—
Sawtoothed grain beetle, adults	5	—	3	10	3	—
Indianmeal moth, eggs and larvae	7	7	—	>14	>4	—
Lesser grain borer, all stages	28	—	—	>28	—	—
Rice weevil, all stages	28	—	>18	—	>28	>18
Granary weevil, all stages	42-56	—	>9	>49	>14	—
Red flour beetle, adults	6	—	3	7	4	2
Khapra beetle, larvae in overwintering stage	—	>18	>17	—	—	14
Cheese/mold mite, all stages ^d	—	>14	6	—	—	—

^aGrain mite species is *Acarus siro* L.; ^bData not available; ^cPsocid species is *Liposcelis bostrychophila* (L.); ^dCheese mite species is

Alternative 2) Use hermetic or airtight storage structures: The use of hermetic structures is sometimes described as an “old” technology (Hyde et al., 1973; De Lima, 1990). Unlike modified/controlled atmospheres that are used to purge commodities or structures (Alternative #1 above), in hermetic storage structures, respiration by insects, molds, and grain results in a lowered resident O₂ level with a concomitant increase in CO₂. Grain stored hermetically must be properly dried to recommended moisture (or dryness) levels for each grain or product. Hermetic storage structures, such as airtight metal drums, have been used successfully for controlling stored-product insects in Africa (Seck et al., 1996; Murdock et al., 2003; and Obeng-Ofori, 2011). GrainPro has conducted a cost-benefit analysis comparing hermetic storage versus alternative storage facilities (<http://www.grainpro.com/>)

Triple-bagging technology, developed by the Purdue Improved Cowpea Storage (<http://www.ag.purdue.edu/ipia/pics>) in collaboration with research institutes in west and central Africa, is a hermetic storage technology in which grain is sealed in two high-density polyethylene (HDPE) sheets which are then placed in a polypropylene outer bag (Murdock et al., 2003). Two HDPE bags of at least 80 – 100 µm thickness should be used to prevent insects from damaging the bags and to obtain effective insect control (Sanon et al., 2011). Extensive tests conducted with cowpeas and the cowpea weevil, *Callosobruchus maculatus* (F.), under laboratory and field conditions (Sanon et al., 2011) showed that this technique was effective in providing very good control of bruchids over the even-month test period without loss of seed germination. Observed O₂ level 5 days after storage was 6%; low levels of insects were alive for at least 28 weeks because of residual O₂ present; therefore, with this technology, some grain damage is expected. The cost of the metal drum is US\$13.6 - 18.8 per metric ton and the cost of triple bags is US\$16.4 – 24.0 per metric ton (Moussa et al., 2011).

Polyvinyl chloride (PVC) cocoons (0.83 µm thick) and SuperGrain bags from Grain Pro (Concord, Massachusetts, US, <http://www.grainpro.com>) are used in many parts of the world. SuperGrain bags are made of co-extruded gas barrier plus 78 µm thick polyethylene. These bags can be used to store up to 100 kg of a commodity. The rectangular cocoons, with two halves that can be sealed airtight by a zipper, can be used to store bagged commodities of 5 to 1,050 tons. They are gas and moisture proof and have an aluminized reflective sheeting to minimize temperature fluctuations. Cocoons have also been modified so that after the commodity is stored, CO₂ or N₂ can be pumped into the enclosure. This is recommended when cocoons are used for processed materials. Alternatively, one can create low O₂ atmospheres by attaching a vacuum pump to the cocoons to suck the air out and create anoxic conditions.

A GrainPro cocoon, which was used to store paddy rice in Bangladesh, offered the best insect control and lowest O₂ levels compared with (a) a Germax cocoon made of polyester fabric coated with PVC, (b) a storage bag made by the International Rice Research Institute, (c) a Rexin cocoon, (d) a polyethylene bag, (e) a thick poly bag, (f) a poly plus gunny bag, and (g) a gunny bag (Alam et al., 2009). The initial O₂ level of 19.1% in the GrainPro cocoon immediately after storage dropped to 3.7% at the end of the storage period (3 months). The insect population was reduced by 99%. All other storage structures had O₂ levels that ranged from 7 to 19% at the end of the storage period, and provided 10 to 94% insect control. The paddy rice moisture content was unaffected (11%, wet basis) because of stable relative humidity inside the cocoon even though ambient temperatures during the study fluctuated from 24 to 34°C.

The hermetic metal bins, triple bags, and SuperGrain bags may be more suitable for storing clean, uninfested spilled commodity in warehouses or commodities from torn bags. These bags may not be best suited for bagging bulk grains delivered at the ports, because the open ends need to be tied or the zipper system has to be sealed manually and would delay filling bags as the grain is being unloaded from vessels. Stitching machines cannot be used as stitches placed on the bags will make them gas permeable.

Efficacy: Effectiveness with modified atmospheres can be rapid (a few days) at high temperatures (30-40 °C) and at low relative humidity because desiccation of insects tends to be faster at lower humidity (Jay et al.,

1971). Effectiveness can be increased if exposure to modified atmospheres occurs under vacuum or high pressures (10-15 bar) (Locatelli and Daolio, 1993; Le Torc'h and Fleurat-Lessard, 1991).

Alternative 3) Use contact pesticides as the primary means of stored-product pest control: There are several contact insecticides that the USEPA has approved for use in warehouses and in food-processing facilities (White and Leesch, 1996). Only contact insecticides belonging to the pyrethroid, organophosphate, and N-methyl carbamate classes are included in this alternative. As a group, all pyrethroids have a similar mechanism of action. Both organophosphates and N-methyl carbamates have a similar mechanism of action; these two classes of pesticides are discussed together below.

Food aid bags/package products should not be treated with insecticides that leave a residue (USAID's CRG prohibits use of residual products in or around bags and recommends their use only in empty warehouses.) This alternative involves pyrethroid and organophosphate/N-methyl carbamate applications to floors, interior and exterior walls of empty warehouses, along aisles among bag stacks, in empty surfaces of containers and also involves fogging. (Compliance requirements of the PEA Tools require that warehouse be empty during applications). Arthur and Peckman (2006) review factors influencing effectiveness of insecticides applied to surfaces.

Natural pyrethrins extracted from the flowers of chrysanthemum grown commercially in Ecuador and Kenya, and their synthetic cousins, pyrethroids, provide quick knockdown of insects; however poisoned insects often recover quickly. Many insects have developed resistance to these chemicals by being able to physiologically break them down. These compounds also breakdown rapidly—often in a matter of hours—in the environment, especially when exposed to direct sunlight. To prevent rapid insect recovery, a synergist chemical called piperonyl butoxide (PBO) is almost always added to pyrethrins and pyrethroids². And, to prevent UV radiation from rapidly breaking down pyrethrins and pyrethroids, UV protectants have been developed and added to the pesticides. Additionally, scientists have developed a second generation of synthetic pyrethroids that are more resistant to UV degradation, and thus last longer in the environment.

Pyrethroids are formulated as wettable powders (WP) or as emulsifiable and soluble concentrates (EC, SC). Wettable powder formulations form insecticide suspensions in aqueous phase, and are best for treatment of absorbent and porous materials, such as brick, cement, concrete, and timber; they are filtered by the surface, resulting in retention of the insecticide powder on the surface (Parkin, 1966).

Organophosphate insecticides, such as chlorpyrifos, chlorpyrifos-methyl, and pirimiphos-methyl and carbamate insecticides such as carbaryl, propoxur, disulfoton, azinphos-methyl, and fonofos are widely used in agriculture and household applications. The toxicity of organophosphates and carbamates to insects and vertebrates is attributed to their ability to inhibit acetylcholinesterase, a class of enzymes that catalyzes the hydrolysis of the neurotransmitting agent, acetylcholine (Fukuto, 1990). Acetyl choline is found in the central and peripheral nervous system, neuromuscular junctions, and red blood cells. Several studies have documented the inhibition of acetyl cholinesterase and serine hydrolases by organophosphate and carbamate esters (Fukuto, 1990). Since the phosphorylated or carbamylated enzyme is no longer capable of hydrolyzing acetyl cholinesterase, the neurotransmitter builds up at a nerve synapse or neuromuscular junction.

² Synergists suppress enzymes responsible for insecticide breakdown in the insect body. Synthetic pyrethroids, such as allethrin, permethrin, cypermethrin, deltamethrin, resmethrin, fenvalerate, cyfluthrin, and lambda-cyhalothrin, to name a few, have improved insecticidal activity, provide long residual activity when applied to surfaces, and improved stability in sunlight compared to pyrethrins (Gosselin 1984). Pyrethroids affect ion channels, primarily voltage-gated sodium channels, in the nervous system and prolong neuronal membrane depolarization, resulting in large amounts of neurotransmitter release (Bloomquist, 1996). Pyrethroids that lack the α -cyano moiety in the molecule are called Type I pyrethroids (permethrin) and those that have the α -cyano moiety are called Type II pyrethroids (deltamethrin). Type II pyrethroids produce more delayed repolarization of the nervous system than Type I pyrethroids.

Pirimiphos-methyl is one of the most effective organophosphates (Huang and Subramanyam, 2005) to use against stored product pests. Malathion is an organophosphate that has been used for many decades worldwide and many insect species are now resistant to it. In fact, resistance to organophosphates and carbamates is common in insect species associated with stored products due to extensive use over the years.

Contact pesticides can also be dispersed in air as aerosols (AE) containing tiny particles, mist or fogs. This process involves the use of dispersing insecticides as a mist or aerosol of approximately 10- μ m size particles to kill insects active in storage structures. Several classes of insecticides are used for fogging; these include synergized pyrethrins, pyrethroids, organophosphates, and Insect Growth Regulators (IGRs) or a combination of pyrethrins or pyrethroids with IGRs (Boina and Subramanyam, 2011). Fogs are applied within seconds to minutes and the mist takes two to eight hours to settle on warehouse surfaces or any live crawling or flying insect bodies. In addition to respiration exposure, insects may succumb to the aerosols by picking-up lethal amounts of insecticides from exposed surfaces.

Aerosols are best suited to control exposed insects, and the particles can disperse and kill insects present beneath pallets, as these particles will drift some distance. Some aerosols degrade within two days (for example, the organophosphate pesticide dichlorvos) while others like deltamethrin have a long residual life (Boina and Subramanyam, 2011). Several hand-held or permanently installed systems can be used for aerosol dispersion. During application, air circulation systems should be turned off, and any other air movement should be minimized. Air movement results in an exponential decay of the aerosol particles and will result in uneven settling on surfaces.

Fogging technology is popular because of its low cost and the ability to do tactical (room-specific) treatments. Treatment costs vary based on the product used, but estimates range from US\$0.003 for 0.006/m³ of storage space. The feasibility of treating only a portion of a facility makes aerosol application a desirable option for facility managers. Fogging can be used in food-aid commodity warehouses only if the commodity is protected by an overlay of plastic sheeting to prevent settling and deposition of insecticides directly onto bags or packages.

Efficacy: The effectiveness of pyrethroids, organophosphates, and carbamates varies with the insect species, life stage, whether or not insects had access to food, temperature, tolerance/resistance to the insecticide, and the type of surface treated—cement, concrete, steel, and tile (Subramanyam and Harein, 1986; Subramanyam and Cutkomp, 1987; White and Leesch, 1996; Johnson 1990; Arthur and Peckman, 2006). Generally, pyrethroids are more effective at cooler than warmer temperatures; pyrethroids degrade at warmer temperatures (Noble and Hamilton, 1985). Organophosphates and carbamates are more toxic at warmer than cooler temperatures, while residual effectiveness decreases with an increase in relative humidity or moisture. Degradation is also greater at warmer temperatures.

Pyrethrins with the synergist PBO, called synergized pyrethrins, are not effective against stored-product insects (Huang and Subramanyam, 2005). If food is present on surfaces treated with contact insecticides, effectiveness against insects will decrease, and insects will recover faster when exposed to pyrethroids (Arthur, 1998).

The main limitation of fogging is that aerosols will not penetrate packaged food. Therefore, insects, mostly in the egg stage, inside packaged food, are unaffected and need to be controlled by another method (i.e., fumigation). To improve control of insects, aerosol applications can be integrated with other management tactics, such as fumigation, application of residual contact insecticides, and sanitation (Toews et al., 2006). Also, aerosols may complement control achieved by insect-resistant packaging. The limitation can also be offset to some extent by fogging empty warehouses and then bringing clean raw, finished, or packaged products into the facility; this reduces the chance of cross contamination and thereby, of infestation. The presence of flour as a food source may decrease the effectiveness of aerosol treatments; therefore, sanitation of the warehouse prior to aerosol application is essential (Arthur and Campbell, 2008; Toews et al., 2010).

Alternative 4) Implement good sanitation practices as the primary means of stored-product pest control:

Sanitation in the case of stored food commodity takes into consideration design of buildings, condition of building exterior and interior, food production practices, and distribution of food (Gould, 1994). Good sanitation practices refer to proper storage of food aid commodities to prevent insect or vertebrate pest infestations, and removal of spillages and clean-up of grain residues in a timely fashion to discourage establishment of insect and vertebrate pests.

Good sanitation practices involve daily, thorough inspections to identify areas where food is accumulating and immediate removal of food sources that allow pests associated with stored grains to infest, seek refuge, and reproduce; stored-product insects require very little food to survive and reproduce (Hagstrum and Subramanyam, 2006). Larson et al. (2008) found very few insects in facilities that were cleaned on a regular basis versus those that were unclean. Sanitation alone, however, will not control stored-product insects, especially the long-lived species that can survive without food for extended periods (Subramanyam and Hagstrum, 1996; Hagstrum and Subramanyam, 2009).

For proper sanitation, building design must facilitate inspection of the storage structure and products and must include techniques to exclude pests from entering the storage structure (Subramanyam et al., 2005). The storage structure must be well lit to enable thorough inspection and must be well sealed to exclude rodents and birds. The facility must be constructed to prevent entry of pests from outdoors via gaps in the storage structure such as outside floor-wall junctions, gaps near doors and windows, and gaps where pipes from the outside lead to the inside (Imholte and Imholte-Tauscher, 1999; Mullen and Pedersen, 2000; Toews et al., 2006). When rodents and birds enter a storage facility, they not only consume commodity, they also can damage bagged/packaged products creating an entry point for pest insects and defecate/urinate on commodities.

Efficacy: Effectiveness of sanitation is dependent on: the ability to thoroughly inspect facilities to determine sanitation issues; the timely removal of all food sources; and the ability to prevent entry of pests. Application of an insecticide, such as pyrethroids, organophosphates, insect growth regulators, or diatomaceous earth should accompany sanitation, because after sanitation activities are performed (such as removing food spillage), insects will actively forage for food sources and will come in contact with the applied insecticide deposits (Roesli et al., 2003). Sanitation also improves effectiveness of insecticides applied to storage surfaces (Arthur and Peckman, 2006).

Alternative 5) Use inert dusts as the primary means of stored-product pest control:

The use of amorphous synthetic silica dusts and diatomaceous earth dusts for pest control has been known for almost a century. Amorphous silica (silica aerogels) is produced synthetically by heating silicon dioxide to high temperatures (Subramanyam and Roesli, 2000). These materials are chemically unreactive in nature; hence they are considered inert dusts.

This alternative involves application of inert dusts to surfaces of storage structures to control stored-product insects. Inert dusts adsorb the epicuticular waxes of insects causing insects to desiccate and die. Compared with diatomaceous earth dusts, amorphous silica has a greater oil adsorption capability, and hence



ABOVE: Diatomaceous earth dusts are derived from fossilized skeletons of fresh or salt water diatoms. The dusts absorb the epicuticular waxes of insects causing dehydration and death.

they are more effective in killing insects than diatomaceous earth dusts.

Several formulations have been commercialized in various countries; the effectiveness of different formulations varies greatly. They are considered safe for human use and are exempt from a residue tolerance (Subramanyam and Roesli, 2000). Inert dusts do not work well on high moisture grains (>14%) and under humid conditions (>70%), because the rate of desiccation (their mode of action) is reduced. Application of dusts affects the physical properties of grains, such as bulk density, flowability, and how grains pile when placed on a flat surface (angle of response) (Korunic et al., 1996) may be adversely affected.

Efficacy: Efficacy varies with relative humidity, type of dust, insect species and stage at which exposed (Arthur and Peckman, 2006). Insect kill is slow and at 28°C and 65% relative humidity, mortality among insect species tested can range from 2 to 14 days (Subramanyam and Roesli, 2000); chemical insecticides act more rapidly.

Alternative 6) Use insect growth regulators (IGRs) as the primary means of stored-product pest control: IGRs are synthetic insecticides that mimic insect hormones so that when insects are exposed to them, they are unable to complete development to the adult stage; for insects in the adult stage, exposure affects the reproductive organs. When larvae are exposed to IGRs they fail to become a pupae; and when pupae are exposed, they fail to become viable adults. IGRs do not kill adults but affect growth and development of immature stages. In exposed adults, the number of eggs laid and egg hatchability are adversely affected (McGregor and Kramer, 1975; Oberlander and Silhacek, 2000; Wijayarathne et al., 2011). IGRs can be applied to surfaces to provide long-term control of insects in storage environments (Arthur and Peckman, 2006).

Efficacy: IGRs may not be effective against the adult stages of insects. Efficacy varies with the insect species. The time to death is not immediate and larvae tend to remain in the larval stage for extended periods (~50 days).

Alternative 7) Use insect-resistant packaging as the primary means of stored-product pest control: Among stored product insects, some are package penetrators, of which certain stages (adults or larvae) can chew a hole in packages and gain entry. Other stored product pest species are invaders, gaining access through already available openings. A majority of common stored product insect adults are able to pass through openings that are <0.25 mm (Cline and Highland, 1981). Young larvae that hatch from eggs can enter through openings smaller than 0.2 mm.

This alternative uses packages designed to protect products from insect infestation. Insect-resistant packaging is packaging that is glued (continuous glues at seams), not stitched; includes an internal bag to contain the product; uses multi-walled paper; and uses odor barriers as an overwrap. Insect-resistant packaging can help prevent insect entry into packages (Mullen and Mowery, 2006); it can control insects, by exclusion, from the point of manufacture to the point of consumption.

Some insect-resistant packaging is impregnated with pesticides. Provisiongard™ is an example of how insecticides can be impregnated into the packaging matrix to repel or prevent insects from entering packages (<http://www.provisiongard.com/empirical.html>). In airtight <http://www.provisiongard.com/empirical.html>. In air tight packages the use of oxygen scavengers can be ideal, especially for processed food aid commodities (http://www.agmcontainer.com/desiccantcity/desiccant_oxygen_absorbers.htm?gclid=CL-pnrGrpLACFSdeTAodExLLXA). http://www.agmcontainer.com/desiccantcity/desiccant_oxygen_absorbers.htm?gclid=CL-pnrGrpLACFSdeTAodExLLXA.

When bags are stitched coarsely which is common practice with food aid commodities, openings remain between the stitches. Food odors emanate from the bags and attract insects (Mowery et al., 2002). An insect-resistant bag without stitches is a solution to this issue.

Efficacy: The level of insect resistance is based on the materials used for packaging, the type of seal, and the package design (Hagstrum and Subramanyam, 2006). Continuous glue or locking type of mechanism, multi-layered bags, and bags without stitches tend to be insect-resistant. The addition of modified or controlled atmospheres to packages prior to sealing is used to control insects and mites in many pet foods, and could be used in some cases for Title II commodities. The use of odor barriers improves insect resistance as well.

Alternative 8) No Action: This alternative involves taking no action against pests. It is presented in the PEA for comparative purposes only. Under the *No Action* alternative, no chemical or nonchemical control is applied for insect management in food aid commodity storage once it arrives from the US and is at the host-country port.

As noted in the Scoping Statement, even with fumigation, USDA and FFP partners have had to destroy many hundreds of mega tons of commodity in recent times due to infestation, although these losses were estimated at 1% or less. Disposing of large quantities of spoiled or contaminated food aid is itself a challenge. The *No Action* alternative would result in a significant increase in the amount of commodity that would have to be destroyed due to infestation. Essentially, the *No Action* alternative would not meet the *purpose* and *need* of this “project”—to control pests in Title II food aid.

Globally, the procurement, transport, storage and distribution of food aid under US Government programs is a massive undertaking involving numerous partners and stakeholders, occurring on a worldwide basis. The total amount of food aid shipped in recent years ranges from a high of 3.716 million kilograms in 2003 to a low of 1.372 million kilograms in 2007³. All of this food aid with the exception of vegetable oil and other commodities packaged in tins is fumigated before leaving the US and then must be protected and occasionally re-fumigated during shipment or once it reaches its destination country and/or local distribution area. If the No Action alternative is chosen, there would be significant food wastage and USAID would not fulfill its Title II commitments to meet food aid needs. Without food aid, many more people in recipient countries would go hungry and die of starvation and suffer from nutrition-related disorders.

3.3 ALTERNATIVES ELIMINATED FROM ANALYSIS AND RATIONALE FOR ELIMINATING THEM

The PEA team used the Scoping exercise to eliminate some alternatives from consideration in the PEA. These, as well as an additional alternative that the PEA team identified, are listed below. The discussions include justifications, mostly due to high costs and scalability concerns, of why the alternatives were eliminated.

3.3.1. ALTERNATIVES PROPOSED IN THE SCOPING STATEMENT AND ELIMINATED BY THE PEA TEAM

(1) Entoletion of milled wheat (use of impact machines): Impact machines (initially called entoletters but now called infestation destroyers) are used in the milling industry to kill insects developing inside kernels of wheat. It also destroys the eggs of stored-product insects in flour prior to bagging (Subramanyam,



³ These figures are taken from the latest USDA/USAID Global Humanitarian Assistance Report (September 2009).

2007a,b; Plarre and Reichmuth, 2000). The entoletion process involves passing raw wheat through a rotor that spins at 1750-2100 rpm. The kernels are thrown against the rotor pegs and steel casing and the kernels containing insects inside are broken and are aspirated after exiting the rotor. The same principle is used for flour that may contain insect eggs, mainly of red and confused flour beetles that are found throughout the milling process (Good, 1937). Commodity throughput, commodity moisture, and rotor speed, all influence the degree of insect control (Plarre and Reichmuth, 2000)

The entoletion process reduces the level of all stages of insects in whole wheat, reducing fragment counts so the commodity is in compliance with the US Food and Drug Administration's (FDA) defect action levels (<http://www.fda.gov/food/guidanc COMPLIANCE REGULATORY INFORMATION/guidancedocuments/sanitation/ucm056174.htm>) for unavoidable and innocuous filth that can occur in processed food. The US FDA's Federal Food Drug and Cosmetic Act established a maximum defect action level of 75 insect fragments per 100 g of flour (Dogan and Subramanyam, 2010); flour containing higher than the prescribed limit is considered adulterated and unfit for human consumption. Millers in the US do not accept wheat containing more than 6 insect damaged kernels per 100 g of wheat compared with the FDA standard of 32 insect-damaged kernels per 100 g of wheat (Kenkel et al., 1993). Kernels damaged by insects have round holes where an internally developing insect has emerged and exited as an adult. The low levels of insect damaged kernels at time of purchase by US wheat millers will result in producing wheat flour that is essentially free of insect fragments. Impact machines are used in the wheat milling industry to comply with this standard, but many mills now have been successfully meeting the federal standards without their use.

Justification for eliminating from PEA: The milling industry uses other pest management practices to control insect infestation of bagged wheat flour (Subramanyam et al., 2005). Entoletion is only one part of an integrated program. Entoletion is a costly proposition, and entoleters consume large amounts of electrical energy to operate (US \$ 80,000/year; Andy Allen, Horizon Milling, personal communication). Entoletion would not be practicable in most Title II recipient programs. On its own, it does not control infestation, unless it is part of a milling process. Additionally, entoletion of grain after receipt in the recipient country may result in broken kernels, which may be unacceptable for Title II commodity.

(2) Application of treatments using temperature extremes and irradiation

Heat and cold treatments. The use of extreme temperatures (Fields, 1992) is attractive and chemical-free, but it is suitable for a limited range of facilities. Cold treatments may be possible where food aid is sent to countries in colder climates, where temperatures reach <15°C. Chillers (<http://temp-air.com/contactus.aspx>; <http://www.coolseed.com.br>; and <http://www.frigortec.de>) produce refrigerated air to cool grain to 15 °C. High temperatures are used to disinfest grain and structures where food is stored or processed (Beckett et al., 2007). Heat from electric, steam, and gas heaters can be used to disinfest empty containers, bins (Tilley et al., 2007), and warehouses (Subramanyam et al., 2011)—high temperatures can only be applied to empty warehouses, silos, or containers storing food aid. Insects succumb in hours when ambient temperatures are raised to 50 to 60°C and maintained for 12 to 24 hours (Dosland et al., 2006).

To heat-treat commodities, special systems are needed, such as spouted or fluidized beds to treat commodities, and a bin to cool heated commodity which can be expensive (Beckett et al., 2007). Both heat and cold treatments require a large capital investment, they are expensive to maintain and operate, and require a reliable source of electrical power. Grain is a poor conductor of temperature, so to maintain grain temperatures with grain chillers below 15°C for extended periods, a constant supply of electricity is required. Commodities subjected to elevated temperatures or chilled air may kill insects or arrest their development but re-infestation can occur as the commodity warms to 20°C or above. Therefore, these treatments are analogous to phosphine treatment in that they fail to provide long-term insect control.

Irradiation. Commodities can be subjected to both non-ionizing and ionizing radiation to kill insects (Halverson and Nablo, 2000). Non-ionizing radiation includes the use of infrared and microwaves while the use of ionizing radiation involves the use of radioisotopes, Cobalt-60 or Cesium-135. There are also

accelerator sources capable of applying energetic electrons (electron beams) directly to the product, and capable of doing this at much higher dose rates than can be achieved with gamma ray sources. Much of the work with microwave and infrared energies has been conducted under laboratory-scale experiments (Halverson et al., 1997; Khamis and Subramanyam, 2011) and commercial use of these technologies is still in its infancy. Treatment with ionizing radiation has been studied for four decades (Tilton et al., 1966; Watters and MacQueen, 1967). Ionizing radiation affects reproductive cells more than somatic cells. Bulk irradiators that can treat 4.5 metric tons of commodity per hour have been built (Tilton and Brower, 1973), but they can cost millions of dollars and annual throughputs of commodity make them less cost competitive compared with existing technologies. They require a reliable source of power.

Justification for eliminating from PEA: The cost of heaters and chillers is expensive (about US\$ 100,000-250,000), and the use of heat treatment requires a facility with natural gas or propane for gas heaters, or reliable power supply for electric heaters, and a boiler for steam heaters. Based on tests at Kansas State University using gas heaters, the cost was US\$2.96 to 3.11/m³ of space (Brijwani et al., 2012). The use of extreme temperatures also requires training in use of these technologies, and the presence of a local provider or company with engineering experience to troubleshoot problems. Maintenance requires that a service provider is present in food aid countries to provide services and repairs if needed. In addition, according to <http://www.aces.edu/pubs/docs/A/ANR-1154/>, small amounts of products can be frozen or heated to kill the insects; but for pest control for large quantities, fumigation is needed.

Non-ionizing radiation has not seen commercial success yet. Ionizing radiation with electron beams and radioisotopes has potential, but it requires expensive equipment with safety considerations. Effectiveness decreases with product depth (Halverson and Nablo, 2000). Efficacy against insects varies with the insect stage and species (Halverson and Nablo, 2000; Khamis and Subramanyam, 2011). For food aid that is bagged, use of this technology would require additional infrastructure and safety factors, and this technology is more suitable for treatment of commodities prior to shipping or bagging in the US and not in the receiving countries. These concerns, along with the initial and ongoing expense, maintenance requirements, and the need for a reliable energy source, make heat, cold, and irradiation alternatives not practicable for use in countries receiving Title II food aid.

(3) Greater use of genetically modified organisms (GMOs) which would be more resistant to insect infestation of food commodities: Transgenic technology is a method of crop protection which can generate “superseeds” that may resist insect attack (Gatehouse and Gatehouse, 1998). Seeds of various commodities exhibit some level of tolerance to infestation, which translates to reduced rates of insect development and reproduction (Throne et al., 2000).

There are three limitations to consider prior to using this technology for commodity protection (Throne et al., 2000):

- i. Traits conferring resistance to one species may not confer resistance to another species attacking the same commodity.
- ii. Insects are overcoming resistance by altering their physiological processes that prevent enzyme inhibition.
- iii. GMO crops are bred for resisting insects and pathogens in the field and not for resisting stored-product insect attack. Therefore, insect resistant factors are not expressed at their maximum in the seeds to protect them from stored product insect attack.

Justification for eliminating from the PEA: Acceptance of transgenic technology worldwide has been controversial, and it is an issue that has to be addressed if this technology will be embraced in the future. To date, commercial companies have not marketed transgenic seeds to claim that they protect them against stored-product insects.

(4) Tiered pesticide application approach: This alternative is described in the Scoping Statement as: lower toxicity pesticides applied first as a preventative measure, with higher toxicity pesticides, such as aluminum phosphide applied only if needed based on observation and data collected, not simply as a matter of routine and time schedule. According to USEPA there are four toxicity categories, based on lethal dose that kills 50% of the tested animals (LD50) based on oral and inhalation routes and based on eye and skin effects (<http://www.fs.fed.us/r6/invasiveplant-eis/Region-6-Inv-Plant-Toolbox/Herbicide%20Info/EPA-Toxicity-Categories-081607ver.pdf>). The least toxic material to mammals may not be the most effective against insects.

Justification for eliminating from the PEA: This is a decision making tool (part of IPM) that should be used when deciding the measures to take to protect food aid commodities. Alternatives for evaluation in a PEA (or EA) should be clearly distinguishable from each other, and should provide a good basis for making comparisons. The tiered pesticide approach fails the alternative formulation test for EAs because it is not clearly distinguishable from the other alternatives being considered herein. The tiered pesticide approach should be a part of PERSUAPs and is a method to ensure that least hazardous pesticides are selected first and the most toxic one as a last resort approach, with due consideration of their costs and effectiveness against stored-product insects. Pesticides that may be considered as possible alternatives to phosphine fumigation are already being considered in this PEA.

(5) Use traditional practices of protection against stored food pests: Annex I contains a description of traditional practices of pest control of stored-product insects. The report was required as part of the SOW. The description in this section of the traditional practices alternative is excerpted from that report.

The use of traditional methods of protection for stored products is very popular among small-scale subsistence farmers. The methods are numerous, diverse and widespread across the continents, with some regional and country differences. The report in Annex I discusses the following storage methods and botanical control methods.

Hermetic storage: Gas tight storage is an ancient way of storing grains. Grain stored under hermetic conditions creates an atmosphere high in CO₂ and low in O₂, thus protecting the stored seeds from insect infestation as these conditions are not conducive for insect production and survival. Hermetic storage methods include underground granaries/pits, earthen pots, metal drums, and off-the-ground mud/dung plastered structures.

Botanical pest control agents: The use of plants and also their local names changes from place to place. Chili pepper and finger euphorbia are among the most commonly used biological pest control agents in most countries in Africa. When grain is stored for seeds, as in some parts of Tanzania, for preservation, farmers sometimes sprinkle urine from a cow or goat or salt over the grain. This is done two days before putting the grain into storage to ensure that it is dry. When salt is only used, the grain can be stored directly after dressing. Farmers in Uganda use banana juice, pepper, Mexican marigold and eucalyptus leaves, for pest control in stored grains (FAO, 2012; Nukenine, 2010). In India, neem leaves are mixed along with ragi, a staple millet food crop for Hunsur region to, keep it free of pests. Additionally, when rice is stored “Umi” or “Husk” is mixed with it in order to keep it free from pests (UNESCO, 2007).

Other naturally-occurring products for protection, such as black pepper and coconut oil (Swella and Mushobozy, 2007) have pest control properties and are used in many countries worldwide for control of insects for post-harvest storage.

Justification for eliminating from the PEA: All natural products and botanicals have to be applied at high rates to commodities and their efficacy is questionable. Many of the natural products are applied as crude extracts, and the active insecticidal component is rarely isolated and tested for environmental stability, adverse health and environmental effects, and long-term efficacy against insects. These natural products have to be admixed with commodities (The CRG prohibits applying insecticides directly to commodities, except in

fumigation.). The currently available—but un-commercialized—natural products are unable to provide effective pest control for the large quantities of Title II food aid. They are more suitable for small, on-farm post-harvest storage pest control, and their practical value for Title II food aid commodities is questionable.

3.3.2. ALTERNATIVE IDENTIFIED BY PEA TEAM, BUT ELIMINATED:

(1) Sulfuryl fluoride: Sulfuryl fluoride is a non-ozone depleting insecticide registered by the USEPA for disinfecting structures and commodities, and is used as a fumigant against pests in stored grains. Several studies have documented the effectiveness of sulfuryl fluoride against stored product insect pests (Bell and Savvidou, 1998; Reichmuth et al., 1999; Schneider and Hartsell, 1999; Wontner-Smith, 2005). It is similar in its gas distribution characteristics to methyl bromide, an ozone depleting gas (Cryer, 2008; Chayaprasert et al., 2012); however there are differences between sulfuryl fluoride and methyl bromide. Sulfuryl fluoride is more effective than methyl bromide at reaching insects residing deep in cracks and crevices, in grain bulks, and in residual flour. Bell (2006) reported that methyl bromide sorption on flour was 750 mg/kg while sulfuryl fluoride sorption was less than 75 mg/kg. Low sorption of sulfuryl fluoride means that it leaves little or no residues on treated commodities when compared with methyl bromide.

Justification for eliminating from the PEA: The pesticide registrant needs to register this chemical in the country of use. The registrant of sulfuryl fluoride, Dow AgroSciences (Indianapolis, Indiana, US) requires all users to go through a competency training program in the use of the fumigant and in the use of a software program (Fumiguide™) that introduces the precision fumigation concept designed to optimize fumigant use, maximize efficacy against insects, and minimize risk to humans, and the environment. Sulfuryl fluoride is registered only in the US, Australia, Europe, and Canada, and according to sources, Dow AgroSciences has no intention to register it elsewhere (Joe Demark, Dow AgroSciences, personal communication). In addition, as with aluminum/magnesium phosphide, an FMP, respiratory protection, and other safeguards must be used; if PPE is not used and safeguards are not in place, sulfuryl fluoride toxicity is similar to aluminum/magnesium phosphide.

3.4 COMPARISON OF ENVIRONMENTAL IMPACTS OF ALTERNATIVES

The matrix below (Table 3) illustrates the relative benefits and adverse impacts of fumigation with phosphine and the alternatives being considered in this PEA. The matrix provides a comparison. The analysis that underlies the comparison is presented in Section 5.

TABLE 3: COMPARISON OF PHOSPHINE ALTERNATIVES

Ratings are made below without considering potential mitigation: +2 significant positive effect; +1 positive effect; 0 neutral; -1 negative effect; -2 significant negative effect

Alternatives	Proposed Action: Fumigate with AP (as currently practiced)	Modified/ Controlled atmosphere	Hermetic storage structures	Use of contact pesticides, i.e., pyrethroids, organo-phosphates, & carbamates	Sanitation	IGRs	Inert dusts	Insect-resistant packaging No pesticides/pesticides	No Action (no fumigation)
Potential significant Impacts									
Health of applicators & on-site workers & visitors (includes transporters)	-2	0	0	-2	0	0	-1	0	0
Health of nearby residents	-2	0	0	-2	0	0	-1	0	0
Commodity quality	0	0	0	-1	0	0	-1	0	-2
Health of beneficiaries	0 (more study needed)	0	0	-2	0	0	-1	0	-2
Water quality, soil, non-target organisms	-1	0	0	-2	0	-1	-1	0	-1 (disposal of infested commodity
Solid waste management	-1	0	0	-2	0	-1	-1	0	-2 (infested commodity will have to be disposed)
Disposal of dead birds & rodents	-1	-1	0	-2	-1	0	-1	-1	-1
Fungal diseases	0	+1	+1	0	0	0	0	0	0

4. AFFECTED ENVIRONMENT

As required in 22 CFR 216.6(c)(4), this section succinctly describes the environment of the area(s) to be affected or created by the alternatives; the descriptions provide the detail necessary to understand the effects of the alternatives. The “Affected Environment” section contains a general description of the social characteristics of those affected by fumigation of Title II food aid on a global scale, as well as the physical and biological characteristics common to Title II countries. As part of the PERSUAP process, PVOs are required to describe the conditions under which the pesticide is to be used, including climate, flora, fauna, geography, hydrology, and soils.

4.1 GEOGRAPHIC CHARACTERISTICS

Title II recipient countries are located in Africa, Europe and Eurasia, Asia-Near East, and Latin America and Caribbean regions (see Text Box 2). Title II food aid to these countries may be for commodity for development or emergency situations. The countries are prone to, or have been affected by natural disasters such as flood, droughts, cyclones or a combination of natural disaster, conflict, and insecurity, thus resulting in food insecurity.

TITLE II RECIPIENT COUNTRIES 2010/2011

African countries		Asia region	Latin American and Caribbean
• Burkina Faso	• Madagascar	• Afghanistan	• Bolivia
• Burundi	• Malawi	• Bangladesh	• Colombia
• Cameroon	• Mali	• Cambodia	• Dominican Republic
• Chad	• Mauritania	• East Timor	• Ecuador
• Republic of Congo	• Mozambique	• India	• Guatemala
• Central African Republic	• Niger	• Kyrgyzstan	• Haiti
• Djibouti	• Rwanda	• Laos	• Honduras
• Ethiopia	• Senegal	• Mongolia	• Nicaragua
• Gambia	• Sierra Leone	• Nepal	
	• Somalia		

For example, some parts of Ethiopia experience drought conditions due to insufficient rainfall. In addition, some areas receive heavy rains resulting in floods and mudslides that wash away food crops and displace people, creating an emergency situation. Therefore, the Government of Ethiopia’s Safety Net Program (PSNP) receives support from USAID’s development and emergency food assistance program. Niger is described as a chronically food insecure country and receives food aid support from USAID. The country is reported to have ranked 167 out of 169 countries in the 2010 United Nations Development Program Human Development Index. Nearly 60 % of the population lives in poverty and over 80 % of the population relies on farming. Threats to Niger’s food security include poverty, crop infestation, and unfavorable weather conditions. Another example of a USAID food aid recipient country, Guatemala, has the highest national level of chronic malnutrition in the

western hemisphere and one of the highest in the world, resulting in its designation as a food deficit country. Food insecurity is most severe in the highlands and some areas in the east where drought is recurrent; most people in these regions rely on subsistence agriculture on non-irrigated land. Liberia is a post- conflict country that receives Title II food aid. Though the country is on the road to recovery, there are residual effects of war resulting in food insecurity. Liberia is working to rebuild its agricultural sector with an aim to transition from food aid to market-driven development (and thus, transition out of Title II food aid).

4.2 SOCIAL CHARACTERISTICS

Beneficiaries are stakeholders involved in Title II food aid are discussed in this section.

Beneficiaries: Title II food aid beneficiaries are directly affected by fumigation (or decisions not to fumigate). Food aid beneficiaries are as diverse as the countries that receive food commodity assistance. Food aid assistance to a country may be for development or emergency relief. Emergency programs are usually one year in length, while development programs last up to five years (FFP, 2012). The purpose for which food aid is provided determines the food aid beneficiaries.

For emergency food aid, a binding factor for the beneficiaries is their vulnerability to the effects of hunger as a result of food insecurity in their respective countries. In this scenario, FFP target beneficiaries include children under the age of five, pregnant women, lactating mothers, the elderly, and the poorest families the food aid recipient countries. Women and children are the largest beneficiary groups. Additionally, there are beneficiaries with the economic ability to purchase monetized food aid commodity or those who benefit through programs such as food for work, school feeding programs, to mention but a few.



ABOVE: A USAID-supported program provides monthly rations to poor families as an incentive to send their children to school. Naz Gul sits outside school in her village of Chakai with her monthly ration of wheat for her family. WFP. 2009.

Food aid earmarked for development may be used to motivate children to attend school, compensate people for work, such as building roads or repairing water and irrigation systems, or improving maternal-child health. Food for development could also be monetized if a recipient country is facing domestic supply shortfalls, which could be filled through commercial imports and food aid, while ensuring that local market prices are not destabilized, but that fair market prices are obtained (USAID-BEST, 2009). In turn, these development projects help protect communities from future hunger by providing them access to local markets for their produce, keeping them healthy and improving their harvests. In this latter category, the beneficiaries are not vulnerable to the effects of hunger but they could be

described as those with an economic ability to purchase monetized food aid commodity or those that may require the following: some form of payment for their labor; food through school children feeding programs to guarantee regular school attendance and hence improve academic performance;

additional or knowledge/skills enhancement in areas such as farming, nutrition, production of high value commodities that could earn money in local markets, to mention but a few (FFP, 2009).

Governments of recipient countries also participate in determining the type of beneficiaries for food aid. For example, the FFP Fact Sheet (2011) on Ethiopia indicates that the Government used their own local eligibility criteria to select their food aid target communities. However, a common factor with FFP's criteria is that the beneficiaries were food insecure.

Table 4 below gives an overview of the type of food aid beneficiaries (as of 2011 to 2012) that can be found globally across select recipient countries.

Stakeholders: FFP describes its work as a collaboration of farmers, businessmen, grain elevator operators, truckers, bargemen, freight forwarders, port operations, non-governmental and international organizations, and government officials. Together these categories of Title II stakeholders are described as forming an unbroken chain of humanity stretching from fertile fields in the US to hungry families half a world away (FFP 2009, 2012).

These stakeholders have different but important roles along the food aid supply chain. Some are involved in agricultural production of food, while others focus on the purchase of food aid, food handling and storage, while another stakeholder category transports the food commodity to recipient countries by sea, land, or rail, and yet another group distributes the food commodity to the beneficiaries in the earmarked communities.

Table 4: Detailed Description of Food Aid Beneficiaries by Country

Recipient Country	Description of Beneficiaries
Djibouti	Chronically food insecure Djiboutian pastoralists and refugees from neighboring Somalia
Kenya	Food insecure Kenyan agro-pastoralists and Somali, Sudanese and Southern Ethiopian refugees
Niger	Malnourished children, pregnant and lactating women in food-insecure households
Afghanistan	Food insecure Afghans in the rural and urban communities
Bangladesh	Households participating in the following development related projects: agriculture; livelihood; maternal and child health and nutrition; infrastructure development; emergency preparedness and disaster mitigation capacity building
India	Food-insecure orphans and People living with HIV (PLWHIV) benefiting from a supplementary food program.
Honduras	Rural food-insecure and marginalized Hondurans in western Honduras participating in the following development related projects: maternal and child health and nutrition; economic and agriculture development; business management; production and marketing.
Madagascar	Food-insecure individuals in select households participating in the following development related projects: agricultural development; natural resource management; health and nutrition; disaster preparation and mitigation

Source: FFP Country Fact Sheets (2010, 2011) <http://foodaid.org/food-aid-programs/food-for-peace/>

Stakeholder groups that may be directly affected by fumigation are a sub-group of the Title II stakeholders (Section 1.6.3). They include fumigant applicant workers (involved in application or use of fumigants); storage facility workers (this group of stakeholders comes into contact with fumigated food commodities); residents living on-site or nearby to the storage facilities; those involved in loading and transporting fumigated food commodity; and the food commodity beneficiaries (discussed above).

Anecdotal data from Uganda, Ethiopia, and Djibouti suggest that women are unlikely to be involved in a fumigation process. The fumigation preparation process is considered laborious, requiring strength that a woman may not possess, i.e., fumigation sheets are heavy and strength is required to pull them over the high food stacks (see Annex J, photos 13 and 14). Women were on the staff in all of the storage facilities that the PEA Team visited. In countries sampled by the PEA Team, men over 18 years of age and with at least a basic level of education make up 100% of the fumigant applicant personnel. Loaders and transporters may have lower education levels than the fumigators.

Other Title II stakeholders who may be indirectly affected by fumigation include bi- and multi-lateral international donor agencies. WFP, a public international organization agency (PIOA) is the world's largest humanitarian agency dedicated to fighting hunger and is entirely funded by voluntary donations (In addition to purchasing and distributing food aid independently of USAID, WFP is a PVO in some Title II countries.). On average, WFP aims to bring food assistance to more than 90 million people in 73 countries globally. Fumigation of Title II food aid commodity can affect WFP

and other donors who address hunger; less efficient, effective Title II food aid could result in increased demand on other donors.

In the fight against hunger, WFP responds to emergencies by getting food aid to the hungry in a timely manner. WFP also works to help prevent hunger in the future through programs that use food as a means to build assets, spread knowledge and nurture stronger, more dynamic communities, thus helping communities to become more food secure. WFP has expertise in a range of areas including food security analysis, nutrition, and food procurement and logistics to ensure the best solutions for the world's hungry.

WFP purchases more than two million metric tons of food every year. At least three quarters of it comes from developing countries as per WFP's policy which requires that food is bought as close as possible to where it is needed. By buying locally, WFP saves money on transport costs and also helps sustain local economies. WFP handles its food aid, generally in partnership with NGOs and government institutions, which are in charge of food distributions in recipient countries (WFP, 2012).

Many bilateral donor agencies contribute to the food aid sector. Bilateral relationships in the food aid supply chain are based on agreements between governments in two participating countries i.e., the donor (bilateral donor) and recipient. This relationship differs among countries. Food aid is granted and distributed on a government-to-government basis. For example, food aid contributions by a donor country could be in the form of "in-kind aid," whereby food is grown in the donor country for distribution or sale abroad. Rather than being free food as such, recipient countries typically purchase the food with money borrowed at lower than market interest rates (Global Issues, 2007).

4.3 ENVIRONMENTAL CHARACTERISTICS: PHYSICAL AND BIOLOGICAL RESOURCES

US food aid programs stretch from sub-Saharan Africa to the former Soviet Union and from Latin America and the Caribbean to south Asia. Given the broad coverage of the Title II food aid program, a discussion of the environmental characteristics is daunting. Rather, below are some key points and considerations of the physical and biological resources that should be taken into account when considering the alternatives that are being evaluated in this PEA.

- USAID food aid programs target "the poorest of the poor." They also respond to disasters, such as the January 2010 earthquake in Haiti and the 2010 and 2011 flooding in Pakistan.
- While the "poorest of the poor" often live in rural areas, poor people have been migrating to urban centers in greater numbers; Title II food aid distribution centers may be located in rural or urban environments.
- The poor often live in areas prone to disasters such as earthquakes and flooding, and they are more affected by natural disasters. Food aid distribution centers may be located in areas prone to disasters.
- The bulk of recipient countries are located in tropical climates. Climate has an effect on the incidence and severity of infestation; the fumigation process; and on the willingness of pesticide applicators to wear PPE. Therefore, of the biological and physical resources, the role of climate may be most important for this analysis.
- The "poorest of the poor" are also the most susceptible to contaminants in water due to malnutrition and reduced body weights. They have fewer options to obtain clean water if water sources are contaminated by pesticides, or for legal recourse.

- Food aid often targets the rural poor, and these locations may also be areas rich in fish and wildlife. Use of pesticides, in particular organophosphates, carbamates, and pyrethroids discussed in this PEA as alternatives to fumigation, can be highly toxic to terrestrial and aquatic receptors.
- Subsistence farmers rely on pollinators to pollinate some crops. Depending on the formulations and method of use, pyrethroids, carbamates, and organophosphates can be highly toxic to some pollinators, including bees.

4.4 POLICY, LEGAL, AND REGULATORY REQUIREMENTS

The two sub-sections below discuss host country regulations with a focus on Uganda, Ethiopia, and Djibouti, and international standards as they apply to fumigants and fumigation.

4.4.1 HOST COUNTRY GOVERNMENT REGULATIONS WITH REGARD TO FUMIGATION

Most food aid recipient countries have in place pesticide regulations that spell out allowable pesticides, and safe handling, storage, application, and disposal procedures, although the degree of enforcement varies. Fumigant application companies may also be required to be authorized or certified to handle and apply fumigants; this may require various degrees of training/certification and re-training/re-certifying.

For example in Uganda, a fumigation company is first expected to register as a company with the Registrar of Companies. Thereafter, an application is put through the Ministry of Agriculture, Animal Industry, and Fisheries (MAAIF) for a license to operate as a fumigator/commercial applicator. The applicant is invited for an interview at the MAAIF, where s/he faces a Board and responds to industry-specific questions about qualifications and training. The Board, which sits once a year, consists of representatives from the Agricultural Chemical Board, National Environmental Management Authority, MAAIF, and the National Agricultural Research Organization. The license issued specifies national and international industry-standards that a company is expected to adhere to. Training is required and entails a three-week training offered by Makerere University, Department of Crop Science. The training focuses on safe handling and application of pesticides. Refresher trainings are only applicable where there is a change in technology or methodologies in pesticide management and handling. Through regular liaison of the fumigation company with Makerere University, the company keeps abreast of emerging technologies and training needs (personal communication with Mr. Maju Champlain, April 10, 2012).

According to Messrs. Bedassa Olana and Said Moussa of Djibouti Pest Control, Djibouti uses international standards to guide the practice (this is typical of many other countries with no specific regulations on fumigation). Through a train the trainer concept, select fumigation applicants are trained in neighboring agriculture-active countries such as Ethiopia and they consequently train their colleagues in Djibouti (personal communication, April 23, 2012). Djibouti's Ministry of Environment is responsible for controlling chemicals, particularly pesticides, to ensure the protection of the environment and human life. The Ministry of Health is in charge of public health (e.g., pesticides for vector control), while the Ministry of Agriculture is responsible for plant and animal protection (e.g., veterinary chemicals and crop pesticides).

For information about international conventions related to pesticides (including banned pesticides) and lists of countries that have ratified them, see

<http://www.pic.int/Countries/CountryProfile/tabid/1087/language/en-US/Default.aspx> ;

<http://www.pops.int>; <http://www.basel.int/>; and <http://www.unep.org/OZONE/pdfs/Montreal-Protocol2000.pdf>.

Discussion of host country policy and institutional frameworks for pesticide use is a requirement of all USAID PERSUAPs. Host country-specific information will need to be gathered when preparing the PVO request (IEE and PERSUAP) to USAID. (An annotated template for a PERSUAP is included as Annex T-2.)

4.4.2 INTERNATIONAL STANDARDS AND BEST PRACTICES

The International Code of Conduct on the Distribution and Use of Pesticides (<http://www.fao.org/agriculture/crops/core-themes/theme/pests/pm/code/en/>) is the worldwide guidance document on pesticide management for public and private entities engaged in, or associated with, the distribution and use of pesticides. It was adopted for the first time in 1985 by the Twenty-fifth Session of the Food & Agriculture Office (FAO) Conference. The Code recognizes, and is mainly aimed at, countries where good regulation and enforcement systems are not fully developed or currently in place. The Code also recognizes that stewardship is not solely the responsibility of industry, but should be supported and promoted by a range of stakeholders. Adherence to the Code is a condition of membership in Crop Life International, a global federation of companies representing the plant science industry.

To conform to the Code, most pesticide distributors have a program of product stewardship. *Product stewardship* is the responsible and sustainable management of agrochemical and biotechnology products throughout their life cycle, which covers development, production, distribution, use, and disposal of pesticide products. Pesticide distributors' product stewardship efforts include training programs to ensure that those who procure their products are storing, transporting, applying, and disposing of them in a safe manner.

Below, USAID (the CRG) and WFP guidance is used to illustrate international practices in fumigation.

The USAID CRG, Section IV: Controlling damage to food commodities (http://www.usaid.gov/our_work/humanitarian_assistance/ffp/crg/sec4.htm) has generic information on pest management. It stresses that anyone using pesticides should read the manufacturer's label and comply with instructions for safety, use, and disposal. Fumigation is recommended to manage insects and rodents that could potentially infest food aid commodities. The CRG states that fumigation will not eliminate molds and bacteria, and that fumigation will not prevent re-infestation of commodities, therefore it places emphasis on sanitation and use of surface sprays and fogs.

The CRG outlines key components for effective and safe fumigation with phosphine: appropriate temperature, proper use of tarpaulins and sealing technique, proper dosage and time exposure, monitoring for presence of fumigants, safety precautions, inspection and follow-up post-fumigation. No detailed guidelines for each of the outlined steps are provided.

The CRG prohibits use of insecticide sprays on and around the commodities/products and recommends they be used only to treat floors and walls of empty warehouses. Insecticide fogs and mists are recommended to kill flying insects and insects that the residual sprays do not reach. To control rodents, the CRG recommends the use of poison bait stations outside the warehouses, and suggests sealing all openings to prevent rodent entry into warehouses. It also recommends the use of snap traps and glue boards, and limited use of zinc phosphide tracking powder in non-food areas to

control mice inside warehouses. The CRG provides no information on fumigator training requirements, the need for monitoring during fumigation, or the need to procure fumigation services from reliable, competent service providers. The CRG pays significant attention to warehouse inspection and other non-fumigation measures to control pests.

The WFP (<http://www.foodquality.wfp.org>) uses Codex Alimentarius guidelines for fumigation of food aid. WFP has SOPs for contracted fumigation. The SOP guidelines suggest fumigation should be performed by trained and certified applicators, and for application speed and safety, teams of two people should conduct fumigation. Fumigation is recommended for the whole store and not just the infested stacks. WFP prohibits fumigation of lined bags and flour, and also prohibits fumigation during windy weather. Based on data gathered in the US, the SOPs state that fumigation sites should be greater than 100 m from human habitation. The fumigation is considered successful if the terminal concentration of phosphine after 5 days is at or above 150 ppm, or at or above 100 ppm after 7 days, especially at temperatures of 25°C or above.

WFP requires implementation of best practices, such as checking warehouse floors for cracks and roofs for water leaks prior to fumigation (rain entering the warehouse could cause a fire hazard when using phosphine tablets/pellets); use of good quality plastic tarpaulins with no tears; placement of two nylon gas sampling lines—one from the top of the stack and one on the side of the stacks just above the ground to measure gas concentration after 5 to 7 days of fumigation; proper alignment and sealing of multiple gas-proof sheets over stacks; placement of sachets or tablets of phosphine below pallets in a single layer on trays; sealing of the sheets to the floor using two rows of sand snakes; closing and locking all warehouse doors; and placing DANGER placards in English and/or the local language.

WFP SOPs state that after 5 to 7 days, fumigators should enter, wearing an approved canister mask for phosphine, and measure gas concentration using a Bedfont electronic phosphine meter (EC80 or better). Gas concentrations of 150 ppm at the top and bottom of the stacks indicate that treatment is effective.

The SOPs describe the aeration process. After fumigation all doors and vents of the warehouse are opened and fumigators should enter the warehouse wearing canister masks and partially remove the gas proof sheets to allow phosphine to clear the warehouse and the stacks. After two hours, fumigators wearing canister masks should measure gas concentrations with detector tubes (http://www.draeger.us/sites/enus_US/pages/Mining/tubes-for-short-term-measurements.aspx) to determine if phosphine gas readings are at or below 0.3 ppm to be considered safe for workers to enter the warehouse.

For disposal, SOPs state that phosphine dust in trays should be buried onsite, if possible, away from the warehouse, at least 50 cm below the soil surface. The WFP SOPs recommend that prior to fumigation, floors and walls should be sprayed with approved residual products to a point of run-off. Details of all pest management activities must be recorded and a fumigation certificate for each stack should be provided to the WFP. WFP also requires that the registered/certified fumigator be present to supervise fumigation and spraying, and that phosphine meters must be calibrated by the manufacturer every six months.

With a few exceptions, the WFP procedures are consistent with proper fumigation procedures described in van Someren Graver (2004). WFP does not require gas monitoring during fumigation nor monitoring of gases outside the warehouse. As stated above, in the US, preparation of an FMP is mandatory prior to fumigation, which requires monitoring gas concentrations both outside and inside treated structures. WFP does not require the preparation of an FMP; nor does the USAID CRG.

5. ENVIRONMENTAL CONSEQUENCES

The Environmental Consequences section describes the potential environmental and health impacts of fumigation and its alternatives. The discussion includes unavoidable adverse impacts, direct, indirect, and cumulative impacts.

Based on interviews and fieldwork, the PEA Team revised the potential significant issues developed during the scoping process. The PEA Team re-phrased the issue statements from the Scoping Statement, and separated one of the issues into two. The Scoping Statement issue regarding dispersal from the fumigation site is now two separate issues, one related to human health impacts to nearby residents, the other related to potential contamination of soil and water, and impacts to non-target organisms. One potential impact included in the Scoping Statement, but excluded from this PEA is noted, and the justification for eliminating it is described below. Potentially significant impacts, as revised by the PEA Team, are evaluated below for all alternatives described in Section 3.

For Issues #1 - #4, much of the information presented below is excerpted from the HHRE. The HHRE includes a detailed discussion of methodology and also describes toxicology basics; it should be referred to for this background information and other more technical information on health risk analysis

5.1 ENVIRONMENTAL CONSEQUENCES OF PHOSPHINE FUMIGATION

Numbers one through eight are the potentially significant adverse impacts as revised by the PEA Team. For Issues #1-4, the following definitions are provided:

- Acute health effects are characterized by sudden and severe exposure and rapid absorption of a substance. Normally, a single large exposure is involved. Acute health effects are often reversible.
- Chronic health effects are characterized by prolonged or repeated exposures over many days, months, or years. Symptoms may not be immediately apparent. Chronic health effects are often irreversible.

Issue 1) Use of the fumigant, phosphine, can affect the health of applicators and other on-site workers and visitors.

For purposes of the HHRE and for this PEA, the fumigator and those aerating the treated area are assumed to be the same person and herein is identified as the “applicator.” The applicator places tarps, applies metallic phosphide at the start of fumigation, and enters the warehouse to start the ventilation/aeration process (remove tarps, open doors and vents). The applicator also enters the warehouse after ventilation/aeration.

“Other on-site workers or visitors” are those who may be on-site during a fumigation event, including truck loaders and transporters. On-site workers continue to work during fumigation, and may be in close proximity to the fumigation warehouse for approximately eight hours a day over the course of the fumigation, but they typically have no direct contact with fumigation chemicals, no contact with the fumigation structure, and therefore, do not have protective equipment to mitigate against exposure to fumigants. An on-site visitor may be in close proximity to the fumigation

warehouse for only minutes or may remain there for hours, and may return over the course of the fumigation period. This category of individual normally would not enter the warehouse until it is re-opened to workers and the public after the fumigation process is complete. (For transporters, potential risk is mainly during their time on-site rather than when transporting commodity; the direction of de-gassing is toward the vehicle behind them.)

The HHRE states that applicators may be exposed to phosphine primarily at three stages of the fumigation process. On-site workers and visitors and nearby residents (see Issue #2) may also be exposed to phosphine during the fumigation process:

- On Day 1, after the tarpaulins are secured to the commodity stacks, trays of aluminum phosphide are deployed. Once the tablets/pellets are removed from their container, the evolution of phosphine commences.
- On the final day of fumigation, applicators enter the warehouse to pull back the tarpaulins so the warehouse can be ventilated.
- During warehouse ventilation, applicators and other workers may be working on-site in the vicinity of the fumigation warehouse.
- Other potential exposures include: on-site workers and visitors, and nearby residents during all stages of fumigation (the warehouses may not be fully sealed).
- When ventilation/aeration is “complete,” applicators and other workers/visitors may enter the warehouse to finish removal of tarpaulins and to conduct other work. Since phosphine monitoring is not performed (see below), the level of phosphine remaining in the structure, which would reflect the “completeness” of ventilation/aeration, is an area of high uncertainty.

As the PEA Team found, and as the HHRE states, poor fumigation practices are common in countries where USAID commodities are shipped. These include, but are not limited to:

- Unsupervised fumigations;
- A lack of use, improper use, and lack of maintenance of personal protective equipment (PPE), especially proper respiratory protection. For example, the PEA Team found that expired and/or inappropriate respirators and cartridges, not meant for phosphine, are being used. See Annex J, photo 12;
- A lack of phosphine concentration monitoring (the PEA Team found that monitoring during a fumigation rarely occurs);
- Use of improper commodity enclosure equipment (for example, the PEA Team found that tarpaulins are used many times over and may have tears, whereas in the US, tarpaulins are typically discarded after a single use); and
- Fumigating in warehouses that are not properly secured (i.e., with open roof vents, gaps between walls or floor and doors, and without adequate sealing and placarding of storage facilities.) See Annex J, photo 3.

Several of those interviewed stated to the PEA Team that applicators monitor gas leakage by odor detection, rather than using monitoring equipment to detect the presence of phosphine gas. However, as the HHRE states, considering the range of possible odor thresholds for phosphine (see HHRE and Table 5), odor is likely insufficient to warn applicators or other on-site workers/visitors of the presence of phosphine at concentrations in excess of the U.S. Occupational Safety and Health Administration (OSHA) Permissible Exposure Limit (PEL) of 0.3 ppm. USEPA indicates that the sense of smell varies from individual to individual and olfactory fatigue may raise the odor threshold (USEPA, 1998).

Table 5: Some Basic Properties of Phosphine and Ammonia

	Molecular Weight (g/mol)	Vapor Density ^{1,2} (Air = 1)	Odor Threshold (ppmv) ³	Odor Threshold (ppmv) ⁴	Odor Threshold (ppmv) ¹	Odor Threshold (ppmv) ⁵	Odor Characteristic ^{1,2}
PH ₃	34.00	1.17	0.51	1.0	1-3	0.02	garlic; decaying fish
NH ₃	17.03	0.597	5.2				Sharp

1 ATSDR, 2011 (PH₃).

2 ATSDR, 2004 (NH₃).

3 Amoores and Hautala, 1983.

4 USEPA, 1992.

5 USEPA, 1998.

Given the above findings, there are concerns that fumigators and other on-site workers and visitors at Title II warehouses may be exposed to phosphine gas. USEPA has classified phosphine as *not classifiable as to human carcinogenicity* (Group D) on the basis of inadequate data in animals and no tumor data in humans. USEPA notes that phosphine has not been associated with cancer in humans, but there is some evidence of chromosomal damage (transient chromatid deletions, gaps and breaks, persistent chromosomal translocations). A relationship between these genetic effects and the development of cancer in humans is sometimes postulated (USEPA, 2003). This appears to be an acknowledgment by USEPA to the work of Garry and co-workers (see below).

The HHRE, with examples excerpted below, describes toxicological data on phosphine gas exposure, as well as specific incidents of exposure. Effects from acute exposure are well documented, but chronic health effects from phosphine gas exposure are less certain. The overall picture painted by the HHRE is that there are potential risks to applicators and other on-site workers and visitors, especially given that aluminum/magnesium phosphide may not be used in compliance with the label.

Toxic effects associated with acute inhalation exposure to phosphine range from irritation to mortality. Symptoms of mild phosphine inhalation may resemble upper respiratory tract infections, such as coughing, nausea, vomiting, diarrhea, headache, fatigue, and dizziness (Memis et al., 2007). Symptoms of severe exposure include lung irritation with persistent coughing, ataxia, paresthesia (tingling), tremors, diplopia (blurred vision), hypotension, weak pulse, jaundice, metabolic acidosis, cardiovascular collapse, oliguria (reduced urine output), proteinuria, and anuria (kidney failure) (Memis et al., 2007). In terms of occupational exposure standards, OSHA cites pulmonary edema, gastrointestinal disturbances, and dizziness as adverse effects in human and respiratory irritation as the adverse effect in test animals (OSHA, 1989). NIOSH cites nausea, vomiting, abdominal pain, diarrhea, thirst, chest tightness, dyspnea (trouble breathing), muscle pain, chills, stupor or syncope (fainting), and pulmonary edema.

In 2011, Preisser, et al. studied 26 cargo-workers exposed to fumigants; four of these individuals were exposed to phosphine during unloading or loading of cargo and while fumigating. All the workers exhibited general symptoms of phosphine exposure. Similarly, Gard News (2011) reported several cases of crew fatalities due to poor ventilation aboard grain cargo ships in which phosphine fumigation was used to kill pests in the cargo holds. These incidents included three fatalities and at least 23 cases of illness; phosphine was detected in the crew quarters (Gard News, 2011). In most cases, exposure occurred due to improper inspection of the vessel to ensure its physical integrity prior to actual fumigation; inadequate care taken by fumigators to ensure that fumigation would proceed as planned; and inadequate guidance provided by fumigators to the crew regarding the risks and management of phosphine (Gard News, 2011).

The HHRE cites a case where exposure to phosphine by 22 fumigators led to temporary (15 minutes to three hours) respiratory symptoms including suffocation, breathing difficulty, and chest tightness.

Neurological symptoms (31.8% reported headaches) and gastrointestinal effects were also observed (Misra et al., 1988, as cited in USEPA, 2003). Crew members exposed to phosphine on a grain freighter exhibited symptoms that included shortness of breath, cough, vomiting, fatigue, headache, drowsiness, paresthesia, and tremor (Wilson et al., as cited in USEPA, 2003). Workers who handled aluminum phosphide tablets have noted numbness and tingling (Misra et al., 1988, as cited in USEPA, 2003).

A Hazard Summary for phosphine (USEPA, 2000) indicates that chronic occupational exposure to phosphine may lead to inflammation of the nasal cavity and throat, weakness, dizziness, nausea, gastrointestinal, cardiorespiratory, and central nervous system symptomology, jaundice, liver effects, and increased bone density. The HHRE provides the documentation on chronic effects of phosphine exposure to applicators and other on-site workers and visitors. The studies below discuss the association between phosphine exposure and developmental/reproductive toxicity, chromosome damage (clastogenicity), increased cancer risk (), carcinogenicity), and possible gender effects.

Garry et al. (1989) conducted a study of 24 fumigators. Of the 24, nine were exposed to only phosphine, 11 were exposed to phosphine and other pesticides, and four had no exposure to phosphine. The authors observed both stable and less stable chromosome rearrangements (translocations) in the workers that were exposed to phosphine and/or other pesticides. The stable rearrangements were observed six weeks to three months after exposure to phosphine while the less stable rearrangements were observed only during the fumigant/pesticide application season.

In a follow-up study to Garry et al. (1989), (Tucker et al., 2003) found that, 20 applicators who used phosphides/phosphine were evaluated for chromosomal translocations. The majority of the 20 applicators had participated in the Garry et al. (1989) study. Of these subjects, seven no longer use phosphine, five applied other pesticides, five use an automated phosphide pellet applicator that greatly reduces exposure inhalation, and eight deploy phosphides manually. The authors indicate that unlike in the Garry et al. (1989) study, fewer translocations were observed in the phosphine applicator group relative to a control group. Tucker et al. (2003) attribute this observation to the use of proper respiratory equipment that was not used in the Garry et al. (1989) study.

Garry et al. (2002) reported the results of their study on pesticide applicators, including those that fumigated with phosphine, from the Red River Valley in Minnesota, U.S. Phosphine is indicated as the only fumigant in common use, although applicators did use other pesticides. Of children fathered by fumigators using phosphine, two cases of congenital cataracts from two different families were observed in 290 children born to 113 phosphine applicators. No family history or other indicating factors were noted. According to the United States Department of Health and Human Services (USDHHS), the frequency of congenital cataracts is 1.1-2.2 per 10,000 live births (USDHHS, 1993, as cited in Garry et al., 2002). Both observed cases were in the right eye, which led the authors to postulate that germ-cell mutation might be the cause, based on other research in this area (Paulozzi and Lary, 1999, as cited in Garry et al., 2002). The authors indicate that, unexpectedly, both children with congenital cataracts were female.

In Garry et al. (1989), the observed chromosome rearrangements were cited as an indication for the need to further evaluate phosphine for carcinogenicity; in particular, non-Hodgkin's lymphoma. Garry et al. (1992) expounded on the possible link between phosphine and non-Hodgkin's lymphoma. Groups of workers that used phosphine as the primary pesticide and a group that used multiple pesticides showed higher rates of chromosome rearrangements during pesticide application periods. Notably, when use of phosphine ceased, there was a significant decline in chromosome rearrangement within one year.

At the occupational exposures to phosphine of less than 2.4 ppm/hour, Barbosa and Bonin (1994) found no association between phosphine exposure and genotoxic or toxicological effects on fumigators; however, Garry et al. (1989) found reversible chromosomal aberrations in fumigators (transient chromatid deletions, gaps and breaks, persistent chromosomal translocations). It is unclear whether the genotoxic effects observed lead to cancer or non-Hodgkin's lymphoma (Garry et al., 1989).

USEPA (1998) noted limitations in the study suggesting mutagenicity (i.e. chromosomal damage) by Garry et al. (1989) (discussed above). As a result, USEPA sponsored additional studies (i.e., Kligerman et al., 1994a and Kligerman et al. 1994b, both as cited in USEPA, 1998) to evaluate the potential for the mutagenicity of phosphine. Kligerman et al. (1994a, as cited in USEPA, 1998) involved exposure of mice to 0, 5, 10, or 15 ppmv phosphine for six hours. Lethargy and shallow breathing was observed at 15 ppmv. A significant reduction in splenocyte cell cycling was observed at all levels, indicating that phosphine is cytotoxic to splenocytes; however, there was no observed effect on bone marrow cells and phosphine did not induce sister chromatid exchange or chromosomal aberrations in splenocytes.

Kligerman et al. (1994b, as cited in USEPA, 1998) involved the exposure of mice and rats to phosphine at 1, 1.25, 2.5, or 5.0 ppmv for six hours a day, five days a week over 11 days. No genotoxic effects were noted in bone marrow cells or peripheral blood lymphocytes. USEPA concluded that phosphine is not mutagenic in bacteria, but is clastogenic in vitro (using portions of a live organism outside of the live organism). Phosphine is not clastogenic in mice or rats, based on in vivo (within the live organism) studies. This conclusion is supported by the results of a two-year inhalation and oncogenicity study in rats (Newton, 1997, as cited in USEPA 1998).

Based on the PEA Team's interviews and findings during field work, applicators may be at risk of acute exposure to phosphine; as stated above, this can occur because best practices are not followed (i.e., tarpaulins may be used many times over, gas concentrations may not be monitored, monitoring equipment may not be properly calibrated). The evidence presented above and additional information in the HHRE and on the USEPA website indicate that acute exposure is potentially a concern when best practices are not used; mitigation is needed to minimize potential health impacts to applicators.

The PEA Team also finds that workers performing non-fumigation tasks on-site and on-site visitors may be exposed to the gas if the adjacent areas are not sealed off, if the tarps on the commodities are not tightly sealed, and if there are open vents in fumigation warehouses. They also may be exposed during aeration. Because of inadequate placarding, sealing, and securing, other on-site workers and visitors may inadvertently enter a warehouse undergoing fumigation. As above, and as indicated in the HHRE, the potential for acute exposure to on-site workers (including loaders and transporters) and visitors poses a possible health concern, and mitigation is needed to minimize impacts of acute exposure on on-site workers and visitors.

The HHRE evaluated a series of acute exposures, but chronic exposures are also possible. There may be concern for chronic exposure if frequent fumigations are performed by the same fumigators. Fumigators may also apply other pesticides, and use of PPE when applying them may not be in compliance with labels. The potential for chronic exposure exists, and precautions should be taken to ensure fumigant applicators suffer no adverse chronic effects.

Of importance, the USEPA indicates that most margin of exposures (MOEs; body burden levels where adverse effects occur) were acceptable when respirators were used. However, the on-site worker and visitor and the nearby resident (see below) will not be wearing respirators and their exposure duration may be much longer than for the applicator. In addition, in cases where

monitoring of phosphine concentrations during ventilation does not occur, applicators will not know when ventilation is actually complete and when the warehouse is safe to enter. This indicates a need to apply mitigation measures not only to protect the applicator, but also to protect all those who may enter the property while a fumigation is being conducted, i.e., other on-site workers and visitors, as well as nearby residents (Issue #2).

Issue 2) Use of the fumigant, phosphine, can affect the health of residents nearby to the warehouse being fumigated.

This PEA defines “nearby residents” and “close proximity” to the fumigation warehouse in accordance with the WFP SOPs, which recommend that for contracted fumigations, fumigation sites should be greater than 100 meters from human habitation. Therefore, these terms—*nearby residents* and *close proximity*—identify residents who live less than 100 meters from the fumigation site.

Immediately adjacent describes those whose homes or businesses are next to the warehouse compound.

At some distance away from the warehouse (undefined because there are so many variables, such as wind and temperature), phosphine concentration is greatly reduced as is the potential for risk. For purposes of this PEA, the fumigation service provider is responsible for identifying the distance from the warehouse that is considered “safe”—where potential risk is greatly reduced. This information would be included in the fumigation management plan (Annex T-3).

According to the HHRE, MOEs are not estimated for the *nearby resident* because USEPA cites no related data (from Mansdorf et al., 1998), i.e., there were no phosphine data in the USEPA RED data for aluminum and magnesium phosphide that adequately represents a residential exposure scenario. However, if the residence is located *immediately adjacent* to a fumigation warehouse, the HHRE states that a case could be made that the residents are exposed to concentrations of phosphine similar to those which the on-site worker and visitor (above) is exposed. Further, the exposure at the residence should be assumed to be 24 hours a day and not eight hours a day as it would be in an occupational situation. The assumption that residential exposure is 24 hours a day is valid because the residents may include sensitive subpopulations, such as a young child, the elderly, or the infirm, who may not leave the residence.

Residents nearby to a warehouse that is being fumigated may be at risk of phosphine exposure if fumigation within the warehouse is not conducted under tightly sealed conditions (WFP’s guidelines assume it is safe beyond 100 meters). Typically, in food aid receiving countries fumigation of bagged commodities occurs under tarps, and the warehouse is rarely fully sealed during the fumigation process (Vents and gaps between doors and floors are common, and even when a warehouse is sealed, these often remain open.) Nearby residents may also be exposed to phosphine during the aeration cycle, when doors are purposefully opened.

Generally, phosphine concentration decreases with distance from the fumigated site (Pratt, 1998). Pratt (1998) reported a decrease in phosphine levels with distance from fumigated bins, stacks, and sheds. In barley fumigated under tarps, gas readings ranged from 100-600 ppm (mean=340 ppm). Air samples within a meter from the tarp on the sides and top was 30-60 ppb; and at 15 meters from the tarp, in a well-ventilated area, it was 4 ppb. Pratt observed the highest readings soon after fumigation when gas concentrations were peaking and during aeration; all of the readings were below the 0.3 ppm threshold (however, this OSHA PEL only applies to workers in good health who are exposed for eight hours a day over a 40 hour work week at most; therefore, it is irrelevant to the nearby resident, who would not be wearing PPE.). Phosphine in the atmosphere is rapidly degraded, and wind aids in rapid loss of the fumigant outdoors (Rajendran and Muralidharan, 2001). The half-life in air is approximately five hours; the degradation mechanism is a photoreaction with hydroxy radicals.

However, there are several recorded cases of phosphine poisoning in adults living in close proximity to warehouses being fumigated. The HHRE states that USEPA (1998) cites two cases of mortality involving residents near fumigation facilities. In August 1989, a woman living approximately 350 feet (just above 100 meters) from a grain fumigation facility in North Dakota, U.S. died. Although factors such as heat and chronic grain dust inhalation confound the case of the woman's death, the woman's husband was treated for loss of peripheral motor control (uncontrollable shaking of the hands and feet), diarrhea, headache, burning gums, lips and teeth, skin irritation, dry mouth and throat, and watering eyes during his hospitalization on October 7, 1989. October 1989 corresponded to the greatest monthly use of aluminum phosphide at the fumigation site and the husband's symptoms were reported to be at their worst when the facility aerator was operating.

The second case (Garry et al., as cited in USEPA, 1998) involved the death of a pregnant woman who was removing laundry from her yard approximately 27 meters (30 yards) from a large grain fumigation facility in a rural section of the U.S. that was not well-sealed. Upon coming into the home, she indicated to her husband that the odor was "real strong tonight." A couple of hours later she went to her local physician who observed tachycardia and vomiting. She died in the hospital approximately three to four hours after bringing in her laundry. USEPA believes that these incidents are likely related to phosphine fumigation.

Due to the PEA Team's findings that warehouses may not be tightly sealed and that gas concentrations are not monitored (during fumigation and aeration), the PEA Team finds that there is a potential for nearby residents to be exposed to phosphine gas. The distance of concern from the fumigation warehouse to the residence is based on site-specific conditions and is a matter for the fumigation service provider to determine in the FMP (If there is a scientific basis to assume that beyond 100 meters residents are safe from the potential effects of fumigation, the PEA Team is unaware of it.). As stated in Issue #1, potential acute and chronic health impacts could result from exposure to phosphine gas; **mitigation is needed to minimize the potential impacts to residents within a distance to be determined on a case-by-case basis; mitigation should apply to all residents within the identified limit.**

Issue 3) The quality of the food commodity may be compromised due to phosphine fumigation. This issue is related to cumulative impact and whether the number of fumigations has an effect on the commodity. (Potential impacts on the health of those who consume the commodity are discussed in Issue #4. Both issues # 3 and 4 are related to the ability of phosphine to adsorb and desorb from food commodity.)

The HHRE and the PEA Team evaluated the issue of sorption/desorption of phosphine from fumigated commodities, focusing on the potential for phosphine or phosphorus-containing phosphine degradation products to remain on fumigated commodities at concentrations that may pose a risk to persons coming into contact with fumigated commodities, especially the ultimate beneficiaries (see Issue #4). The following is a summary of the most reliable data on sorption/desorption (from a review by the HHRE and the PEA Team).

Commodities sorb phosphine through both physisorption, a reversible process that allows for phosphine to desorb over time, and chemisorption, which is non-reversible (Berck, 1968). Berck (1968) reported that chemisorption is generally slow and is dependent upon temperature, time and the moisture content of the commodity.

Robinson and Bond (1970) postulate that sorbed phosphine will undergo air oxidation to diphosphine, and the oxyacids hypophosphite, phosphite, and ultimately ortho-phosphate (these phosphorus compounds are much less toxic than is phosphine). Tkachuk (1972) supports Berck's assertion (Berck, 1968) that not all phosphine is recovered during commodity aeration and agrees

with Robinson and Bond (1970) that phosphine appears to form non-volatile (i.e., not phosphine) residues.

Dumas (1980) reported that wheat fumigated with phosphine continued to off-gas phosphine for 220 days (over seven months). While the majority of phosphine desorption occurred during the first three days of aeration, after 71 days, phosphine was measured at 0.01-0.02 nanograms per gram (ng/g, which is equivalent to $\mu\text{g/kg}$). After 220 days, the residual phosphine in the wheat was measured at 0.0002-0.004 ng/g.

Reed and Pan (2000) studied the effect of repeated fumigation of hard red wheat on phosphine sorption in both sealed drums and open bins. Repeated fumigations were found to reduce the phosphine sorption rate into the wheat. The authors concluded that repeated fumigations were not likely to add significant amounts of phosphine to the wheat, and did not result in an increase in phosphorus content of the various fractions milled from wheat. Matthews et al. (1970, as cited in Plimmer, 1977) indicate that baked products made from wheat that had been fumigated with phosphine exhibited some deterioration of physical qualities.

Minor amounts of sorbed phosphine bind to proteins in wheat (Tkatchuk, 1972). The magnitude of gas uptake is based on the type of grain, its condition, and relative quantities of gas to grain. In dry grains phosphine sorption is 0.05-0.20/day. Paddy rice, but not brown or milled rice, and high moisture grain absorb phosphine rapidly (Banks, 1990). Dumas (1980) reported that in wheat and corn treated with 0.5-5 mg/kg (ppm) at 25, 45, and 85°C, the amount of phosphine adsorbed was influenced by length of phosphine exposure and grain temperature. Adsorption not chemisorption was observed. The majority of the phosphine desorbed in the two to three days of aeration, but small amounts continued to desorb for many weeks and at 200 days phosphine still was desorbing in small amounts (10-12 g).

Corn treated with 0.5 mg/kg and aerated for 26 days desorbed 0.004 ng of phosphine in 48 hours. This could be a concern in large-scale fumigation of commodities. Rauscher et al. (1972) have also reported that cereal products do not chemisorb applied phosphine. The loss of phosphine through leakage and desorption in wheat stored in unsealed bins was positively related to grain moisture (11.1-13.5%) and grain temperature (20-30°C) (Reed and Pan 2000).

However, Berck (1968) reported chemisorption of phosphine in his tests with raw cereal commodities and milled products exposed to 0.15-0.60 mg/L. Uptake of phosphine by wheat gluten powder, middlings, bran, and shorts was greater than that by wheat starch, flour and wheat germ. Berck provided presumptive evidence that phosphine binds to proteins and complexes with mineral components of the substrates tested.

Although phosphine tends to be more sorbed by pulses (cowpeas, pea, and mung), aeration for couple of days after a 5-day fumigation reduced tolerance levels to 0.01 ppm (Singh and Srivastava, 1980). Washing and cooking further reduced residue levels. Phosphine did not adversely affect seed germination. Different legumes desorb phosphine at different rates (Rangaswamy and Gunasekaran 1996), and aeration times should be altered to ensure all of the gas has desorbed to acceptable residue (0.01 ppm) levels.

Phosphine can be used to treat processed products in polypropylene bags that are stacked in heavy paper cases or cartons and has the ability to penetrate packaged products (McGregor et al., 1966). However, in order to comply with the 0.01 ppm tolerance for phosphine residues in processed food, a 48 h aeration period is required.

Based on discussions the PEA Team had in Uganda, Ethiopia, and Djibouti, the HHRE noted the issue of residual (i.e., unreacted) aluminum or magnesium phosphides in or on fumigated commodities. The application of the metallic phosphides on trays below stacks of commodities (common practice, as the PEA Team found in Uganda, Ethiopia, and Djibouti) would essentially remove the risk of residual metallic phosphides on the commodities being fumigated; however, given the range of Title II countries and fumigation practices, there is a chance that in some cases, metallic phosphides may be applied directly to commodities. Theoretically, if the amount of metallic phosphides deployed is grossly over the amount needed, the reaction may not proceed to completion, but it is anticipated that this scenario would be extremely rare.

The HHRE mentions a case where samples of wheat with 13.8% moisture content had been fumigated in boxcars and aerated for two weeks were found to contain a mean value of 0.04 ppm (mg/kg) phosphine. Berck (1968) indicates that such traces of phosphine were “faintly detectable by smell.”

The HHRE makes the following comments on sorption:

- Berck (1968) indicated that residual phosphine was detectable by smell. This suggests that not all of the 0.04 ppm was irreversibly sorbed;
- While Reed and Pan (2000) indicate that repeated fumigations were not likely to add significant amounts of phosphine to the wheat, if Berck (1968) is correct in his theory that phosphine binds to proteins, the nutritional value of a commodity could be affected;
- The literature suggests that there is potential for residues of phosphine to remain on fumigated commodities for extended periods of time (months) and oxidation of phosphine to oxyacid species is also a possibility; and
- Two primary types of packaging materials are used for Title II food aid: those that are gas-permeable and those that are not gas-permeable. There may be variations in the degree of permeability for those that are gas-permeable. Based on a review of sorption and desorption processes described in the literature, the ease with which phosphine is able to permeate a package should reflect its ability to be removed via aeration. However, the issue of phosphine residues discussed earlier in this section still remains.

As stated, the effect of fumigation on food quality is related to phosphine’s ability to adsorb/desorb from food commodity. However, the potential impacts of fumigation on food quality are not completely understood. This uncertainty indicates 1) there may be a need to implement mitigation measures; and 2) there is a need for additional research in this area.

Phosphine reduces the amino acid cystine to cysteine in vitro (Bond et al., 1969); phosphine reacts with metals such as iron or copper (Rajak, 1971). Also, as mentioned above, baked products made from wheat that had been fumigated had some deterioration of physical qualities. Therefore, mitigation/best practices would involve avoiding phosphine fumigation of processed/fortified foods. WFP does not allow fumigation of wheat flour and blended products. Processed commodities with live insects would be considered adulterated and the use of fumigation does not change that status.

Besides fortified foods, even though some studies indicate food quality may be affected by fumigation, the potential impacts are minor, especially as compared to the potential for infestation and the risk of losing the commodity if it is not fumigated. Based on most studies, if commodities are aired properly, there will be no issues with phosphine residues; depending on the temperature, commodity aeration may take 1 to 5 days. However, verifying if the phosphine gas within stacks or in treated commodity (by opening the bag) is ≤ 0.3 ppm would provide a rational basis to determine if complete aeration has occurred. This aeration period and other safeguards are easily implemented

by Title II programs, and would serve to minimize concerns. For example, both the USAID CRG and the WFP SOP for fumigation state that the fumigant should not be in contact with the commodities; tablets should be placed in trays below the pallets, or if sachets are used they should be hung on the sides of the stacks under the tarps.

Issue 4) Beneficiary populations may be at risk from inhalation, preparation, and ingestion of fumigated commodities.



ABOVE: Three young girls participate in USAID-supported food security projects. S. Dominguez. 2008.

Beneficiary populations identified in the PEA are lactating women, children under five, and chronically malnourished individuals who may be more susceptible to neurological or immunological impacts of exposure to phosphine residues. Scientific evidence has shown (see above and the HHRE) that phosphine residues can persist in fumigated commodities. The following discussion is from the HHRE and other relevant literature and provides an evaluation of the potential for impacts to beneficiaries (vulnerable populations) that may inhale, prepare, and/or ingest fumigated commodities.

Phosphine comes in contact with food aid commodities in the gaseous phase, and (as

stated in Issue# 3 above), there may be negligible residues in the treated commodities following fumigation and aeration. Research suggests that phosphine residues may remain in fumigated commodities for several months or more and that higher concentrations of phosphine during fumigation may result in greater potential for residual phosphine in fumigated commodities. The HHRE states that there is potential for beneficiaries to ingest phosphine if there is chemisorbed phosphine remaining in fumigated commodities. For the estimation of ingestion risk (in the HHRE), a sensitive receptor (a young, 10-kg child) is assumed to ingest 0.1 kg (100 g) of fumigated commodity a day for two years. From these assumptions, the concentration of phosphine that would have to be in the fumigated commodity at the threshold of risk/no significant risk was estimated to be 0.03 ppm. This concentration is less than USEPA's allowable tolerance of 0.1 ppm for many commodities, although processed foods and pod vegetables have an allowable tolerance of 0.01 ppm. As such, ingestion of phosphine from fumigation of food commodities poses a relatively small risk, though the available data are not sufficient to make a complete assessment.

There is evidence that adsorbed phosphine will tend to oxidize to less toxic oxyacids of phosphorus. Food preparation, especially cooking, may remove most, if not all, residual phosphine. Depending on the phosphine residuals, there may be some level of exposure via inhalation during food preparation. (This potential risk pathway was beyond the scope of the HHRE.)

The chronic Reference Dose (RfD), the amount of pesticide that could be consumed daily, likely without an appreciable risk of adverse effects, for phosphine is 0.0003 mg/kg-day. This RfD is based on the NOAEL (No Observed Adverse Effect Level) of 0.03 mg/kg-day from a two-year feeding study in rats (USEPA, 2003). A phosphine residue of 0.03 mg/kg is needed to achieve a Hazard Index of 1 (i.e., the threshold for potential risk) for a young child weighing 10 kg and consuming 0.1 kg of the fumigated food daily for two years.

The preparation of the HHRE included an Internet literature search (using Science Direct and Google Scholar) to evaluate whether there is the potential for phosphine to be transferred from mother to infant via the ingestion of breast milk. No research papers were uncovered on this topic. As discussed above, there has been research on the transformation of phosphine to less toxic phosphorus species within fumigated commodities. However, the kinetics of those transformations and the kinetics of human metabolism of low levels of phosphine are important to understanding whether phosphine might persist long enough in a fumigated commodity or in the mother's body (i.e., the kinetics of human metabolism of low levels of phosphine) to suggest the possibility of transfer from mother to infant. This is an area where more research is needed to accurately assess potential impacts.

In most cases for Title II food aid, it would not be feasible to monitor the residual concentrations of phosphine in fumigated commodities once the commodity has left the fumigated warehouse. As a result, the HHRE states, if a residual concentration of phosphine is present subsequent to fumigation, estimating the potential risk to the beneficiary via ingestion [inhalation and food preparation] may be a difficult task. Aluminum and magnesium phosphide are in Toxicity Category I, the highest (most toxic) of four categories for acute effects via the inhalation route. However, USEPA expects no significant exposure to phosphine gas via the oral or dermal routes; this is the case where typical fumigation best practices are in place. This may not be the case in Title II recipient countries.

The discussion of potential impacts to beneficiaries is not intended to apply to any specific beneficiary of Title II food aid. It does, however, support the position that good fumigation practices—proper commodity stacking, handling, and warehouse ventilation/commodity aeration—are important parts of the fumigation and commodity protection process so that potential exposure to phosphine via inhalation, preparation, and ingestion routes, is kept to the lowest feasible levels.

Given the current state of knowledge, and that the HHRE indicates that the potential for residues is real, it is impossible to find that there is no potential risk to beneficiaries. Mitigation—as above-good fumigation practices, can minimize potential adverse effects. Additional research is needed to determine health risks, if any, to beneficiaries.

Issue 5) Phosphine fumigation can affect water quality, soil, and non-target organisms.

Aluminum phosphide and magnesium phosphide are non-persistent under most environmental conditions and are non-mobile in soil because of their instability at atmospheric moisture contents (USEPA, 1998). The products of hydrolysis, aluminum and magnesium hydroxides, react to produce mineral phases that occur naturally in the environment. Inorganic phosphate and other phosphorous oxyacids are the other products formed from the oxidation of phosphine gas in soils.

Under normal environmental conditions, phosphine exists as a gas. Phosphine below the soil surface is quickly adsorbed and degraded. The small amounts of phosphine present in spent residues will degrade in days and is at low risk for contaminating ground or surface waters. Phosphine near the soil surface will diffuse into the atmosphere and be removed by photodegradation. Phosphine trapped beneath the soil surface will bind to soil, inhibiting movement, and will be oxidized to phosphates. Therefore, aluminum and magnesium phosphide are not expected to pose a significant ecological risk to soil and water resources under normal circumstances of use.

If phosphine disperses from the warehouse site, non-target organisms could be at risk. One of the main concerns regarding non-target organisms is if aluminum phosphide is used to control burrowing animals (not when it is used to treat food aid commodities). The USEPA has required that precautions be taken to protect endangered species when using any of the phosphine producing

fumigants to kill rodents in burrows. Any non-target species inhabiting the burrow will also be killed. However, this PEA analyzes fumigation of food commodities only, not for use in natural rodent burrows in soil or vegetated mounds.

The greatest concern for environmental contamination is if spent phosphine residues are not properly disposed of; the spent residues can still contain 3-5% phosphine (see Annex J, photo 22). In addition, dispersal of phosphine gas from the site could impact non-target organisms and mitigation is needed, as above (Issues 1 and 2) to ensure fumigation sites are well sealed. Further, best practices for disposal of phosphine residues must be implemented to ensure no soil or water contamination results.

Issue 6) Poorly handled solid waste, such as combining various types of waste (including aluminum and magnesium phosphide residues/byproducts), could present a danger. Mixing toxic residues during disposal could have unforeseen effects. Poor handling of fumigants includes poor practices in transport and storage, as well as disposal (see Annex J, photo 11).

[The PEA Team expanded this issue, identified in the Scoping Statement, to include transport and storage.]

Aluminum/magnesium phosphide and phosphine residues must be handled with caution to minimize risk to applicators, on-site workers and visitors, nearby residents, and firefighters. Improper transport, storage, and disposal or inactivation of residues and phosphine generating formulations can result in exposure to phosphine gas, fires, and explosions. In Title II recipient countries, safeguards may not be in place to ensure proper handling (during transport, storage, and disposal). However, by implementing simple best practices, no impacts would be expected to result. Although they may not currently be in place, these best practices are easily implemented and practical for all Title II recipient countries (see Annex T-6).

Issue 7) Improper disposal practices of rodents and birds, etc. killed by the fumigant, phosphine, could affect human health.



Phosphine can be used to control rats and mice and many other burrowing rodents. Although it is not labeled for control of birds, it is toxic to them. Rodents and birds can enter warehouses where doors are not closed tightly during normal operating hours. As witnessed by the PEA Team, it is common practice in tropical countries to keep warehouse doors open during working hours to allow for ventilation and temperature control (see Annex J, photos 2 and 9).

When warehouses are fumigated, rodents and birds that have inadvertently entered the warehouse will die. Dead animals can spread disease to humans, presenting a potential hazard

for warehouse staff. The greatest hazard related to dead animals is the potential for the indirect spread of human disease by live animal parasites such as fleas and ticks. Risk of exposure to fleas and ticks increases when handling dead animals, because these parasites are actively seeking a live host and may be abundant on the dead animal or in the immediate area. Carcasses must be carefully disposed of to minimize the potential for transmission of disease to humans (Corrigan, 2001; Mamadaliyev et al. 2007; <http://www.pestproducts.com/bird-diseases.htm>).

Proper practices for rodent and bird disposal (as well as measures for keeping rodents and birds from entering warehouses) can be easily implemented to minimize risks. These are discussed in Annex T-6.

8) Phosphine may not be effective for the control of fungal contamination.

Mycotoxins are produced under certain conditions in the field or in storage on commodities. Mycotoxins could affect the health of beneficiaries if they consume contaminated food and advisory levels have been established for various mycotoxins associated with food. Phosphine gas can reduce the rate of mold growth and mycotoxin production but does not provide complete control of molds (Khair and Safeulla, 1994). Phosphine's effect on molds and microorganisms was observed during the late 1960s (Sinha et al., 1967; Raghunatan and Majumder, 1969). Phosphine-treated wheat and rice showed decreased mold development (Hocking and Banks, 1991a,b; Castro and de Pacheco, 1995). Castro et al. (1992) observed complete arrest of aflatoxin production on shelled peanuts fumigated at 0.5 g/m³ for 14 days. Similarly, aflatoxin production by *Aspergillus flavus* was effective on corn, and phosphine concentration tended to have a greater effect than exposure time (Castro et al., 2000). *Fusarium verticillioides* was tolerant to phosphine under high moisture conditions, and *Penicillium* on freshly harvested corn were also tolerant to phosphine. In a toxigenic species of *Aspergillus parasiticus* NRRL 2999, phosphine concentrations of 400 ppm or higher arrested growth of the fungi on agar plates (Antonacci et al., 1999). However, after venting to air, 100% of fungal colony forming units (CFU) initially exposed to <300 ppm developed fully grown colonies, but only 50% of the CFU on plates exposed to 400 ppm or high developed fully grown colonies some reduction at higher phosphine concentrations. Corn inoculated with the same fungi and exposed to 1000 ppm phosphine showed reduced mycelial growth and complete absence of the mycotoxin for over 20 days.

Higher phosphine concentrations may be needed to adversely affect fungi and mycotoxin production. The degree of control of molds and or mycotoxin production is temporary and may vary with the species of fungi present. These laboratory trials suggest that phosphine fumigation may indirectly and adversely affect mold development and mycotoxin production, but after the gas dissipates, fungal growth and mycotoxin production may reoccur.

The only effective control of fungal diseases is to maintain 13% moisture level in the commodity and to distribute commodity quickly so once it arrives in the host country, moisture level has no chance to increase to 14.5% or higher, a level that promotes mold growth.

5.1.1 ENVIRONMENTAL CONSEQUENCES OF THE ALTERNATIVES TO FUMIGATION WITH ALUMINUM PHOSPHIDE

This section contains an evaluation of the potential significant impacts (Issues 1 to 8 above) of the alternatives to the use of the fumigant phosphine.

Modified/controlled atmospheres: For this alternative, CO₂ and N₂ used for treatment of commodities in chambers or in stacked bags under tarps is delivered using 99.9% pure gas in pressurized cylinders to create hypoxic conditions. Nitrogen is an unreactive gas and is considered inert. But exposure to high N₂ atmosphere along with a lack of O₂, will result in CO₂ accumulation in the human body and can cause asphyxiation (Fowler et al., 1985); also, exposure to high levels of CO₂ and low levels of O₂ can be dangerous. Gases are delivered to enclosed areas from cylinders or generators, so the only risk to applicators and other on-site workers and visitors would be from entering treated areas or by accidental exposure.

Oxygen can be toxic at levels of 19% or below and above 60%. Symptoms include dizziness, impaired thinking, seizures, unconsciousness, pulmonary toxicity, or death depending on the severity

of exposure (Clark, 1974). Carbon dioxide acts as both a stimulant and depressant on the central nervous system (OSHA, 1989; Wong, 1992), and adverse effects are related to the concentration and time exposed. Exposure of humans to 17 to 30% CO₂ concentrations leads to unconsciousness, coma, convulsions, and death within one minute (OSHA, 1989; CCOHS, 1990). Exposures of 10 to 15% cause dizziness, drowsiness, severe muscle twitching, and unconsciousness within minutes (Wong, 1992; CATAMA, 1953; Sechzer et al., 1960). Symptoms at <10% CO₂ concentrations include headache, increased heart rate, shortness of breath, dizziness, sweating, rapid breathing, mental depression, shaking, and visual and hearing dysfunction that were seen following exposure periods of 1.5 minutes to 1 hour (Wong, 1992; Sechzer et al., 1960; OSHA, 1989). Short-term exposures (5 to 22 minutes) to carbon dioxide-air mixtures (2 percent to 8.4 percent carbon dioxide) also caused a distinct hearing loss (Gellhorn and Spiesman, 1934; 1935).

No potential impacts to nearby residents or to vulnerable populations (beneficiaries) are likely. There are also no potential impacts to soil or water from implementation of this alternative. Contribution to solid waste is minor. Disposal of bird and rodent carcasses due to this technique presents the same issues as fumigation with aluminum phosphide. This alternative may retard fungal growth, as these microorganisms are aerobic.

Hermetic storage: There are no potential impacts to human health or the environment from hermetic storage structures because modified atmospheres are created with airtight enclosures by commodity respiration; by creating a vacuum; or by purging CO₂ or N₂ into the enclosures (suitable for processed commodities). These systems are self-contained and there is no direct human exposure or exposure to the environment. There are also no effects on food aid beneficiaries (vulnerable populations). Airtight enclosures retard fungal development because of reduced oxygen levels. Rodents and birds are unable to enter hermetic storages; there would be no need to dispose of dead rodents and birds.

Use of contact pesticides (including fogging): This alternative covers the use of pyrethroids, organophosphates, and carbamates.

Use of pyrethroids can have negative impacts on mixers/loaders, applicators, on-site workers and visitors, nearby residents, and on beneficiaries. Pyrethroids can have environmental effects also--water and soil, and non-target organisms may be affected. Pyrethroid containers contribute to solid waste and need to be disposed of safely per label requirements and local ordinances. Disposal of rodent carcasses killed by pyrethroids presents the same issues as with fumigation. Pyrethroids are not used for controlling storage fungi.

The acute toxicity to mammals varies with the specific formulation. Use of natural pyrethrins and synthetic pyrethroids without appropriate safeguards may cause contact dermatitis and produce asthma-like reactions, although absorption through the skin is minimal. Other symptoms of acute toxicity due to inhalation (which could affect applicators, other on-site workers and visitors, and nearby residents) include sneezing, nasal stuffiness, headache, nausea, incoordination, tremors, convulsions, facial flushing and swelling, and burning and itching sensations. The most severe poisonings have been reported in infants (on-site visitors or nearby residents), who are unable to efficiently break down pyrethroids (ETN, Pyrethroids, 1994). If ingested by beneficiaries or by using pyrethroid containers as food containers (a potential impact for applicators, other on-site workers and visitors, nearby residents, and beneficiaries) nervous symptom affects may occur, which include excitation and convulsions leading to paralysis, accompanied by muscular fibrillation and diarrhea (ETN, Pyrethroids, 1994). Death may occur, as well, and is due to respiratory failure. Symptoms of acute exposure last about two days.

Rats exposed to Type I pyrethroids exhibit aggression, hyperexcitability, fine tremor, prostration with coarse whole body tremors, increased body temperature, coma and death (USEPA, 2011). Behaviors observed after exposure to Type II pyrethroids include pawing and burrowing, salivation, hyperexcitability, abnormal hind limb movements, coarse whole body tremor, sinuous writhing, coma and death. The onset of neurobehavioral effects occur within a few minutes to over an hour, depending on the route of exposure and the chemical, but can take 2 to 8 hours to peak. Recovery from pyrethroid toxicity is rapid, typically within 24 to 48 hours, because of the limited absorption of some pyrethroids in mammals and rapid biodegradation through ester hydrolysis and oxidation by liver enzymes.

Some pyrethroids are classified by USEPA as possible human carcinogens, because they contain human-made, or xenoestrogens, which can increase the amount of estrogen in the body (Garey et al., 1998). Certain pyrethroids demonstrate significant estrogenicity and increase the levels of estrogen in breast cancer cells (Go et al., 1999). Pyrethroids, especially those registered prior to 1976, were not teratogenic in rats, mice, and or rabbits (Miyamoto, 1976). They were also not mutagenic to several bacteria strains. A recent USEPA cumulative risk assessment of pyrethroids (USEPA, 2011) concluded the recommended use practices for pyrethrins and pyrethroids provides sufficient margin of safety.

Non-target organisms may be adversely affected by pyrethroids and pyrethrins. They are extremely toxic to aquatic organisms, including fish such as the bluegill and lake trout, with LC50 values less than 1.0 ppb. Lobster, shrimp, mayfly nymphs and zooplankton are the most susceptible non-target aquatic organisms (Mueller-Beilschmidt, 1990). The non-lethal effects of pyrethroids on fish include damage to the gills and behavioral changes. Pyrethroids are moderately toxic to birds, with most LD50 values greater than 1000 mg/kg. Birds can also be indirectly affected by pyrethroids, because of the threat to their food supply. Waterfowl and small insectivorous birds are the most susceptible (Mueller-Beilschmidt, 1990). In soil the half-life of cypermethrin can be 8 weeks, and in water it can be 100 days (ETN, Cypermethrin, 1996).

The synergist PBO is added to natural pyrethrins and pyrethroids to increase their potency against insects by suppressing enzymes. PBO is added in surface and/or fogging applications. PBO inhibits hepatic microsomal oxidase enzymes in laboratory rodents. Chronic toxicity studies have shown increased liver weights, even at the lowest doses, 30 mg/kg/day (USEPA, 2011). PBO exposure leads to skin irritation, anorexia, vomiting, diarrhea, intestinal inflammation, pulmonary hemorrhage and possibly mild central nervous system depression. Animal studies have shown hepatocellular carcinomas at treatments levels as low as 1.2% (Takahashi et al., 1994).

Pyrethroids unlike pyrethrins break down slowly when exposed to sunlight light, heat and moisture, and since warehouses are devoid of sunlight surface residues may persist for weeks to months. For example, deltamethrin products persist from 1 to 2 weeks in the environment (ETN, Deltamethrin, 1995).

For Title II commodity warehouses, pyrethroids and pyrethrins would most likely be used for general surface, spot, and crack/crevice application in and around warehouses. Dermal exposure and inhalation exposure are the main risks during and after application. Wearing a long sleeved shirt, pants, boots, goggles, coveralls, and approved canister type of respiratory protection during application reduces dermal and inhalation exposures. Pyrethroids have low vapor toxicity so breathing vapors post-application is not a concern. Potential impacts to workers may occur if they work in warehouses with bare feet. During PEA site visits, the PEA Team noted that most of the warehouse workers did not use footwear. The use of boots or other footwear would minimize risk due to dermal absorption of residues.

Post-application inhalation exposure due to the use of indoor foggers may occur if during application full face respiratory protection is not used by the applicators. Dispensing fogs using a permanently installed system poses the least exposure risk to applicators/workers. Labels provide information about the need to cover commodities during application.

The CRG recommends application of residual products only to empty warehouses. During site visits, the PEA Team found that treating empty warehouse floors and walls and outside with pyrethroids prior to bringing in food aid commodities is a common practice. Prior to a fumigation event, pyrethroids are used in empty warehouses to treat the floor-wall junction and floor areas to control insects escaping from tarped commodities during fumigation. Risks to beneficiaries can occur from pyrethroid residues only if the sprays are applied directly or accidentally to the bags. Risk of residues contaminating the commodity may occur only if commodity spilled on the floor is collected and rebagged for distribution to beneficiaries. The pattern of use of applying pyrethroids to surfaces of the warehouse greatly diminishes any adverse impact to beneficiaries, because of lack of direct commodity exposure.

Use of organophosphates and carbamates can have negative impacts on mixers/loaders, applicators, on-site workers and visitors, nearby residents, and on vulnerable populations (beneficiaries). They can have environmental effects also--water and soil, and non-target organisms may be affected; however, the magnitude of adverse effects varies with the product. Containers contribute to solid waste and need to be disposed of safely. Disposal of rodent carcasses that succumb to these pesticides presents the same issues as fumigation presents. Organophosphates and carbamates are not labeled for the control of storage fungi.

The mechanism of action of organophosphates and carbamates, on both target and nontarget species, is irreversible inhibition of acetylcholinesterase enzyme (AChE) found in red blood cells and in nicotinic and muscarinic receptors in nerve, muscle, and gray matter of the brain. Plasma acetylcholinesterase is found in the central nervous system white matter, pancreas, and the heart. Its decrease results in a decrease of cholinesterase activity in the central, parasympathetic, and sympathetic nervous systems.

Organophosphates will phosphorylate and carbamates will carbamylate the serine hydroxyl group at the site of action of acetylcholine. This irreversible binding, deactivating the esterase, results in accumulation of acetylcholine at the endplate causing persistent depolarization of skeletal muscle, resulting in weakness and involuntary muscle twitching (fasciculations). In the central nervous system, neural transmission is disrupted. If this block is not reversed by a strong nucleophile such as pralidoxime (2-PAM) within 24 hours, large amounts of acetylcholinesterase are destroyed.

Chronic neuropsychological effects have been seen in 4 to 9% of patients exposed in occupation-related use (Alavanja et al., 2004; Eskenazi and Maizlish, 1988). Glutathione transferase polymorphism 1 (GSTP1) genotypes may predispose people exposed to organophosphates to develop Parkinson's disease (Menegon et al., 1998; Bhatt et al., 1999). Organophosphate-induced neuropathy has also been implicated to cause amyotrophic lateral sclerosis (Rainier et al., 2008).

Human birth defects have been associated with exposure to the organophosphate chlorpyrifos. In pregnant laboratory animals, exposure to chlorpyrifos caused fetal death. Pups that survived were smaller than pups from unexposed mothers, and also showed decreased survival. Male rats exposed to chlorpyrifos caused cell death in male rat testes and a decrease in sperm production in exposed cattle. Chlorpyrifos has caused genetic damage in human blood and lymph cells, mice spleen cells, and hamster bone marrow cells. Immune system abnormalities have been reported from patients exposed to chlorpyrifos (Cox, 1994). PVOs reported to the PEA Team that the organophosphate pirimiphos-methyl was one of the products of choice. This product is more toxic via dermal

absorption (acute LD50 to rats, 1505 mg/kg) than by inhalation (acute LD50, 2050 mg/kg). According to the USEPA's pirimiphos-methyl fact sheet (<http://pmep.cce.cornell.edu/profiles/insect-mite/mevinphos-propargite/pirimiphos-methyl/insect-prof-actellic.html>) it is not a dermal irritant or sensitizer. It did not cause delayed neurotoxicity at 10 mg/kg/day for up to 90 doses, is not teratogenic, mutagenic, and does not affect reproduction. The product is metabolized quickly and does not bioaccumulate.

In developing countries, Eddleston et al. (2008) estimates organophosphorus pesticide self-poisonings kill 200,000 people a year. A recent cumulative risk assessment by USEPA for organophosphates (USEPA, 2006) and N-methyl carbamates (USEPA, 2007) concluded that the current use patterns of these compounds provides sufficient margin of safety to applicators/workers. This is the case only if precautions are taken.

Most organophosphorus pesticides are chemically unstable and are degraded by microbes in soil and water. Enhanced biodegradation of many organophosphorus pesticides, upon their repeated applications to soil and water, is well-established (Cáceres et al., 2010). Several soil microorganisms, bacteria in particular, are able to transform many organophosphorus pesticides. For example, fenamiphos can undergo rapid microbially mediated degradation via oxidation to its oxides (sulfoxide and sulfone) and eventually to CO₂ and water in soils, or via hydrolysis, in cultures of the soil bacterium, *Brevibacterium* species.

The USEPA fact sheet for pirimiphos-methyl shows that it is toxic to birds by oral and dietary routes. The tested birds include mallard duck, ring-necked pheasant, and bobwhite quail. It is toxic to cold water fish (rainbow trout) and warm water fish (bluegill, sunfish) at <3 ppm. Fresh water invertebrates such as *Daphnia* are susceptible at 0.21 ppb.

Like organophosphates, carbamates do not cause delayed neurotoxicity. Evidence is lacking about the adverse health effects from long-term exposure at levels that do not affect acetylcholinesterase levels. Carbamates are not regarded as mutagenic, carcinogenic or teratogenic substances (USEPA 2007). Carbaryl, a commonly used carbamate, has a half-life of hours to days at a water pH of 7 or above and degradation is about 1500 days at a pH of 5 (<http://www.cdpr.ca.gov/docs/emon/pubs/fatememo/carbaryl.pdf>). It is toxic to aquatic invertebrates (*Daphniamagna*, shrimp), vertebrates (rainbow trout, catfish, and blue gill sunfish) as well as beneficial insects, such as honeybees (LD50 1.54 – 26.5 g active ingredient [a.i.]/bee).

Carbaryl has a low vapor pressure, 1.17×10^{-6} mmHg, and is not readily volatilized into the air. In water, the primary degradation route is by hydrolysis, which is pH dependent, and microorganisms accelerate the rate of degradation. Some degradation is expected due to sunlight. Carbaryl is not persistent in soil. It can be degraded through hydrolysis, photolysis, as well as by microorganisms.

As with pyrethroids, organophosphates and carbamates should not be directly applied to food aid commodities. However, these products may be applied to floors and walls of empty warehouses. Application around bagged stacks is a common practice prior to fumigation of stacks to kill insects escaping the fumigation. The chance of food aid commodities directly coming in contact with these products is minimal, if sprays are made away from stacks. Another source of cross contamination with these pesticides can occur if spilled commodity material on the treated warehouse floors is put back into bags and sent to beneficiaries. Therefore, on treated warehouse floors, collected spilled commodity materials should be discarded. There is no evidence to suggest that application of pyrethroids, organophosphates, and carbamates to empty warehouses or to warehouses with food aid commodities away from stacked bags poses a potential adverse impact to beneficiaries.

Insect growth regulators (IGRs): This alternative has minimal potential for adverse effects on applicators, other on-site workers and visitors, nearby residents, beneficiaries, water, and soil. However, it may have adverse impacts on non-target and beneficial insects. Safe disposal is a consideration for use of IGRs. IGRs have no effect on rodents, birds, or molds.

The USEPA (1991) fact sheet

(http://www.epa.gov/oppbopd1/biopesticides/ingredients/factsheets/factsheet_igr.htm) considers methoprene and s-hydroprone as having the same mechanism of action but the IGR pyriproxyfen's mechanism of action is different (http://pmep.cce.cornell.edu/profiles/insect-mite/mevinphos-propargite/pyriproxyfen/pyriprox_tol_0802.html). The IGRs are generally placed in USEPA Toxicity Categories III and IV based on dermal and oral toxicity to rats, dogs, and rabbits (LD50s > 2000 to 50,000 mg/kg). Methoprene is exempt from a residue tolerance because of its low mammalian toxicity. The acute (four hour) inhalation LC50 for racemic methoprene in the rat and guinea pig is >210 mg/L. Methoprene does not cause any skin or eye irritation. These data indicate an extremely low potential for acute toxicity to humans from overexposure to methoprene via the oral, dermal, ocular or inhalation routes of exposure.

Chronic feeding studies with rats and mice fed 0 to 5000 ppm daily for two years did not result in any adverse health effects even at the highest dose as compared to control animals. Methoprene is not oncogenic or mutagenic and does not affect the endocrine system. Methoprene in animals does not impair developmental or reproduction, suggesting lack of developmental toxicity in humans during pregnancy or during early childhood. In two decades of methoprene use, including stored grain, no health hazards have been reported that could be related to the ingestion of methoprene residues. In water, methoprene is degraded quickly by microorganisms and sunlight to form at least fifty products. In soil, under aerobic or anaerobic conditions, the half-life is 10 to 14 days. Various studies indicate that methoprene is not an oncogen, developmental toxicant, or mutagen. Further studies indicate no detectable endocrine effects in mammals (USEPA, 2001).

Impacts to those who mix, load, and apply IGRs are expected to be minimal due to the low mammalian toxicity via dermal and inhalation routes. Impacts to others on-site also are expected to be low or non-existent. Wright (1976) arrived at these same conclusions based on research on several IGRs.

Methoprene has a moderate vapor pressure and has the potential to volatilize from water or moist soil. Binding to soil may retard volatilization (Csondes, 2004). In air, methoprene degrades by sunlight to hydroxyl radicals (half-life 1.5 hours) and ozone (48 minutes). Methoprene showed rapid degradation in both sterile and nonsterile pond water exposed to sunlight, more than 80% of applied methoprene was degraded within 13 days (USEPA, 1982). Extensive studies have shown that methoprene breaks down rapidly in the environment and displays relatively low risk to most non-target organisms (USEPA, 1991).

Methoprene undergoes demethylation, hydrolysis and oxidative cleavage in microbes, insects and plants and is rapidly metabolized in fish, birds, and mammals (Glare and O'Callaghan 1999). Acute, short-term and sub-chronic aquatic effect studies have been conducted on non-target adult and immature arthropods, including Crustacea, Insecta, and Mollusca. These studies reported 24 and 48 hours LC50 values greater than 900 ppb (Glare and O'Callaghan, 1999). Other non-target organisms in early life stages (nymph, larvae) and non-target organisms that are closely related to mosquitoes such as dragonfly (order Odonata or suborder Anisoptera) are not affected by methoprene up to 1,000 ppb (Glare and O'Callaghan 1999). Methoprene is slightly toxic to aquatic macroinvertebrates such as Daphnia, Mysid and Hyallela (Siemering 2004). Methoprene is moderately toxic to cold water and freshwater fish and practically non-toxic to warm water fish. The reported LC50 are 4.62 ppm for bluegill, 4.39 ppm for trout, and >100 ppm for channel catfish and largemouth bass, and

methoprene bioaccumulates in the fish body (Glare and O'Callaghan, 1999). Use of methoprene could result in impacts to some non-target species if safeguards are not in place. The discussions on health and environmental consequences are from the pyriproxyfen MSDS (<http://www.cdms.net/ldat/mp48S001.pdf>) and from data provided by the Pest Management Regulatory Authority of Health Canada (http://www.hc-sc.gc.ca/cps-spc/alt_formats/pacrb-dgapcr/pdf/pubs/pest/decisions/rd-dh/rd2007-03-eng.pdf). Like methoprene, the acute toxicity of pyriproxyfen is low. It can be minimally toxic when inhaled or ingested. Therefore, fumes of pyriproxyfen from a fire could pose an inhalation hazard. Combustion products are carbon monoxide, carbon dioxide, oxides of nitrogen and water vapor. It is an eye and skin irritant. Chronic exposures produced liver, kidney, and red blood cell changes, but not cancer. People with kidney and liver disease may be susceptible to pyriproxyfen exposures. No developmental and reproductive toxicities were observed.

IGRs have lower mammalian toxicity than pyrethroids, organophosphates and carbamates. The careful application of these products only to warehouse surfaces and walls will not result in direct contact with the bagged food aid. If permanently installed systems or foggers are used to disperse the IGRs, covering the bags with polythene sheets protects from the aerosol coming in contact with the commodity. Given the use pattern, there is essentially no risk to the beneficiaries consuming food aid. As mentioned above, any spilled commodity in treated warehouses should not be rebagged for distribution to beneficiaries. Instead it should be discarded (this is included as a best practice below).

Inert dusts: Inert dusts are chemically unreactive in nature. Inert dusts have low mammalian toxicity and are placed in USEPA Toxicity Category IV. The USFDA considers them *Generally Regarded as Safe* (this rating is related to consumption only). These products are also exempt from a residue tolerance when used on surfaces or commodities (Subramanyam and Roesli, 2000).

Two special journal volumes presented risk assessments of silica-based products (Goldsmith et al., 1995; 1997). Some diatomaceous earth dusts and synthetic silicas may contain none or <1 to 4% crystalline silica. In 1996, the International Agency for Research on Cancer (IARC) changed the classification of crystalline silica from a probable human carcinogen (category 2A) to confirmed human carcinogen (category 1) (<http://www.osha.gov/dsg/topics/silicacrystalline/index.html>).

Therefore, when using DE or silica dusts there is concern about inhalation hazard to applicators. Silicosis is an irreversible lung disease in which fibrous tissue is formed as a response to inhaling the silica particles. The link between silicosis and lung cancer is unknown, but acute and chronic exposures to crystalline silica may cause cancer (Checkoway et al., 1993). In the US, inert dusts have been in use for many decades and no adverse effects have been reported in applicators. However, in Title II recipient countries, where safeguards may not be properly used or available, the potential to cause cancer is a concern. There are no environmental concerns (soil, water, non-target organisms) or concerns to beneficiaries from using these inert dusts. Containers can be disposed of in regular sanitary waste streams. This alternative has no effect on rodents, birds, or molds.

Packaging: Packaging is an alternative to fumigation to prevent insect entry into stored commodities. Unless packages are treated with an insecticide or extruded with insecticide in the packaging matrix, the risk from packaging has no adverse effects to anyone handling the bags or consuming the product.

Packages impregnated with insecticides may pose potential health effects to workers involved with handling the bags (dermal exposure). Packages with insecticides may also have adverse effects on soil, water, and non-target organisms if improperly disposed, and on beneficiaries if translocation of the insecticide into the commodity occurs. Disposal is an environmental concern for packages impregnated with chemicals. Insect-resistant packaging has no effect on rodents, birds, or molds.

5.1.2 POTENTIAL ADVERSE IMPACTS EXCLUDED FROM CONSIDERATION

The Scoping Statement had considered and then excluded the following potential impacts from the PEA:

- **Inappropriate risks associated with pesticide use:** Are they using banned pesticides for fumigation purposes and if so, why? This matter is not considered significant because it is understood that the use of methyl bromide, now prohibited because of its negative impacts on the ozone layer, has been banned from fumigation programs worldwide.
- **Post-Harvest Storage loss in FFP Development Programs is a related topic but beyond the scope of the present PEA.** FFP may wish to consider working with the Bureau for Food Security to address post-harvest loss, either as a separate PEA or general program study in the context of the broader Feed the Future (FtF) initiative.
- **Disposal of Spoiled Food Aid Commodities is another closely related issue but one that will require separate and concerted attention** beyond the means of the planned PEA.
- **Food Aid Quality** as a broader issue will not be considered here because pest infestation is only a small part of the wide range of characteristics currently being considered as part of an effort to enhance food aid quality. See for example the May 2011 GAO Food Aid Quality report.

The PEA Team has excluded the following issue, identified in the Scoping Statement, from further consideration in the PEA:

Confusion about pesticides intended for use in sanitizing warehouse facilities and grounds:

The Scoping Statement describes this issue as: Pyrethroids are commonly applied for crack, crevice, and spot spray treatment in and around an empty warehouse. However, some deltamethrin or cypermethrin synthetic pyrethroids, are being applied improperly on food aid commodities and contaminating them.

Justification for excluding from the PEA: Synthetic pyrethroids and organophosphates/carbamates are discussed in the PEA as alternatives to phosphine for suppressing insects present in empty warehouses or containers. This is not a potential significant adverse impact of aluminum or magnesium phosphide fumigation (the potential impacts that are being evaluated in this PEA), but rather an impact of improper use of insecticides in general, which should be addressed in PERSUAPs.

5.2 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

The proposed action, fumigation of food aid commodities, when undertaken in accordance with best practices (discussed in Annexes T- 2, 3, 4 and 9) would result in only minor irreversible and irretrievable commitment of resources. There is no irreversible commitment of land area (disposal of residue and packaging requires a deep pit, which is typically located on the warehouse site, in an already disturbed area. Once it is filled in, it will revert to natural conditions). Phosphine fumigation results in no irreversible and irretrievable commitment of ecological resources; as shown above in Section 5, potential environmental impacts are minor.

The safeguards required to ensure that human health remains unaffected by fumigation require a commitment of financial resources to implement training, ensure proper PPE is available and maintained, and to conduct possible follow-up studies, as suggested in Section 1.

However, as described, the proposed action (fumigation of food aid commodities with phosphine) often includes pre-fumigation application of contact pesticides. Use of contact insecticides (belonging to the pyrethroid, organophosphate, and N-methyl carbamate classes) prior to fumigation may result in irreversible and irretrievable commitment of resources. The potential impacts resulting from the use of contact pesticides prior to fumigation will need to be analyzed separately in a PERSUAP, and measures should be proposed to mitigate impacts; if mitigation is unavailable or impossible, the PERSUAP should make note that there may be irreversible and irretrievable commitment of resources. Without further country, site-, and pesticide-specific evaluation, no determination can be made at this point regarding irreversible and irretrievable commitment of resources from pre-fumigation spraying.

Modified atmospheres and hermetic storage would require financial commitments. In addition, the significant energy requirements would result in irreversible and irretrievable commitment of energy resources (coal, hydropower, etc.) No mitigation is available to minimize the potential impacts from the high demand for energy.

No irreversible and irretrievable commitment of resources would result from other alternatives considered in this PEA: inert dusts, IGRs, and sanitation. Essentially, these are part of IPM, as mentioned in Section 5.3.

5.3 MEANS TO MITIGATE ADVERSE HEALTH AND ENVIRONMENTAL IMPACTS

The following section discusses the means to mitigate potential impacts of the alternatives, with a focus on the proposed action, phosphine fumigation of Title II food aid commodities. Mitigation measures are presented in Section 5.3.1 and in Annex T-7. Partner compliance requirements consistent with this section are synthesized in the Tools Annexes; partners that follow instructions in the Tools Annexes will satisfy the requirements of the PEA.

As shown in Table 3 and as discussed in Section 5.1, significant adverse impacts may result from fumigation. The main concerns are for the health of fumigators, other on-site workers, visitors, and nearby residents (these populations are rated -2 in Table 3). Typical best practices—for example, as implemented in the US—can minimize potential health concerns. However, as stated above, the PEA Team found that best practices are often not applied in Title II food aid fumigation.

Yet many of the best practices are inexpensive and simple to implement (i.e., use of good quality, undamaged tarps, good sealing of stacks, adequate warning signs on the outside of warehouses, adequate notification of workers and nearby residents). Annex T-6 describes these best practices. Of particular interest for USAID Title II PVOs may be the product stewardship programs that reputable distributors provide; these programs offer training opportunities and advice for PVO staff who fumigate and for fumigation service providers.

Some of the best practices are IPM practices that, in concert with fumigation, minimize the need to fumigate. Yet, as mentioned above, the PEA Team found that some common IPM measures are currently not broadly applied in food aid warehouses, or they are poorly applied (i.e., good sanitation practices, keeping warehouses closed-to the degree acceptable in hot, humid climates--so pests are unable to enter, use of rodent traps). Annex T-6 describes these best practices.

Other best practices, such as monitoring phosphine gas during fumigation and wearing required PPE are more costly. These items need to be procured and maintained, and personnel must be trained to

use them. Recurrent training and replacement parts must also be made available. However, the cost of monitoring equipment and PPE, maintenance, and training is not expected to be prohibitive; various means are available to obtain regular training (including online, see Annex T-13), and equipment is available at a range of costs (See Annex T-9).

Annex T-7, the Programmatic Environmental Mitigation & Monitoring Plan, lists mitigation (best practices), responsible parties, and monitoring and reporting requirements. Fumigation “best practices” are presented in Annex T-6; with implementation of these, adverse health effects to fumigators, other on-site workers, visitors, and nearby residents are not expected to result.

Additionally, potential impacts to these groups could be minimized by improvements to infrastructure. However, the cost of these improvements to USAID and PVOs, as well as warehouse ownership issues, may preclude implementation of improvements. Infrastructure improvements are recommended as a mitigation measure since in certain cases, funding may be available.

While many studies indicate that potential health effects to beneficiaries is less likely an issue than potential effects to those in direct contact with the fumigant (as above, fumigators, other on-site workers, visitors, and nearby residents), as noted, insufficient information is available to make a definitive determination. It is likely that with implementation of best practices (mainly, providing for an adequate aeration period and placing phosphine beneath pallets rather than directly on commodity), concerns are minimal. These mitigation measures are easily implemented and are at no cost. Given the uncertainty further study is called for on the effects to Title II beneficiaries.

Potential effects of fumigation on soil, water, and non-target organisms can be mitigated by ensuring safe storage, transport, and disposal; these are easily implemented, no cost best practices (Annexes T-6 and T-7).

As shown in Table 3, and as discussed above, use of contact pesticides would require mitigation as well. Potential significant adverse impacts to applicators, other on-site workers, visitors, and nearby residents could result (rated -2 in Table 3). As with fumigation, training, use of PPE, and implementation of best practices in handling (storage, transport, mixing, application, and disposal) are needed to mitigate potential human health and environmental impacts. Critically, use of contact pesticides has the potential for significant adverse impacts to the environment (rated -2 in Table 3). These potential impacts can be difficult to mitigate and monitor. For the USAID Title II program, a PERSUAP is required prior to procuring or using pesticides, and this would require detailed mitigation, including training, the use of PPE, and implementation of environmental safeguards.

Except for the *No Action* alternative, none of the other alternatives under consideration have the potential to result in significant adverse impacts. Yet some of the alternatives (modified/controlled atmospheres and hermetic storage) may face other constraints: they may be cost-prohibitive, they require a reliable power supply, and they may have significant maintenance needs. While these would not preclude their use, before recommending widespread application of these controls, additional exploration is needed. On a case-by-case basis, they may be practicable and effective.

Concerns over efficacy limit the usefulness of other alternatives: sanitation, IGRs, inert dust (IGRs and inert dust would require a PERSUAP prior to use/procurement). While on their own, they will not control infestations of stored pests within a commodity, in combination with fumigation they can decrease the number of fumigations needed. In essence, this is IPM; and as required in all cases where pesticides will be used or procured, USAID advises that they should only be used within an IPM framework. Pesticides, including fumigants, should be used as a last resort control, and the least toxic, effective pesticides should be used first.

5.3.1 RECOMMENDATIONS: MITIGATION MEASURES TO MINIMIZE POTENTIAL ADVERSE IMPACTS OF PHOSPHINE FUMIGATION OF TITLE II FOOD AID

Note that the requirements in this section are consolidated in a user friendly format in the Tools Annexes. Partners that complete the templates and plans in the Tools Annexes will be environmentally compliant with their requirements.

COMPLIANCE WITH 22 CFR 216

Programs without Existing PERSUAPs for Fumigation

- 1) If the PVO has provided assistance for the procurement or use of aluminum/magnesium phosphide without an approved PERSUAP (i.e., if the PVO has fumigated or purchased fumigation services at their Title II warehouse, but has not received USAID/DCHA/Bureau Environmental Officer (BEO) approval of a PERSUAP which includes the fumigant), the PVO shall note this in the next Environmental Status Report (ESR), and shall, as soon as possible, take corrective action by preparing a PERSUAP for procurement and/or use of the fumigant.
- 2) The PERSUAP for procurement or use of aluminum/magnesium phosphide shall integrate mitigation measures (see #3 below) guide implementation, monitoring, and reporting on mitigation measures.
- 3) For integration into the PERSUAP, the PEA best practices (Annexes T-6 and 8, with supporting Annexes, T-2 and 3) may be modified to fit the country-, project-, and site-specific situation. However, the PEA BPs are standards that have been identified to minimize the potential for significant impacts to human health and the environment. The PVO should justify the need for modifications, and should identify any additional measures the PVO will take to monitor to ensure adverse impacts will not result from fumigation with aluminum/magnesium phosphide.
- 4) The PVO shall report on implementation of mitigation (successes, issues, failures) in Title II semi-annual progress reports and in the annual ESR.

Programs with Previously Approved PERSUAPs for Fumigation

- 1) If the PVO has an approved PERSUAP for aluminum/magnesium phosphide, the PVO shall review the PERSUAP to determine whether modifications are needed to comply with the PEA.
- 2) As necessary, the PVO shall submit an amendment to the IEE with a PERSUAP.
- 3) For integration into the PERSUAP, the PEA best practices (Annexes T-6 and 8, with supporting Annexes, T-2 and 3) may be modified to fit the country-, project-, and site-specific situation. However, the PEA BPs are standards that have been identified to minimize the potential for significant impacts to human health and the environment. The PVO should justify the need for modifications, and should identify any additional measures the PVO will take to monitor to ensure adverse impacts will not result from fumigation with aluminum/magnesium phosphide.

- 4) The PVO shall report on implementation of mitigation (successes, issues, failures) in Title II semi-annual progress reports and in the annual ESR.

MITIGATION MEASURES

Based on the analyses in Section 5.1, the following mitigation measures will minimize potential adverse effects of phosphine fumigation of Title II food aid. Mitigation is separated into measures to be implemented by PVOs and measures to be implemented by USAID.

MITIGATION MEASURES FOR IMPLEMENTATION BY COOPERATING SPONSORS

A) To minimize the potential adverse impacts related to:

Issues 1 through 7: Use of the fumigant, phosphine, can affect the health of applicators and other on-site workers and visitors; the health of nearby residents; food quality; the health of beneficiaries; and soil, water, and non-target organisms. Inappropriate practices in handling (transport, storage, and disposal) and in disposing of dead rodents and birds could result in adverse health and environmental impacts,

- 1) PVO shall use Annex T-4, Model RFQ and Contract (or revised) when procuring fumigation services, which require that the fumigation service provider (FSP) complies with best practices (BPs), such as fumigation tarp specs, use of PPE, phosphine gas monitoring, securing the warehouse, notifications, safe disposal etc. (Full details of BPs are in Annexes T-6 and T-7, with supporting material in Annexes T-2 and 3).

PVO shall evaluate proposals/quotes from pest management companies based on their ability to implement the BPs stipulated in the RFQ and Model Contract.

- 2) If PVO finds that FSPs are unable to comply with BPs and Model Contract in Annexes T-6 and T-5, PVO shall take corrective actions, such as:

- Sponsoring a meeting with FSPs to identify compliance concerns;
- Procuring phosphine gas monitoring equipment;
- Procuring PPE;
- Procuring fumigation sheets;
- Providing training for PVO and/or FSP staff in use and maintenance of the above;
- Investigate good stewardship programs offered by pesticide distributors; and/or
- Other measures that would address non-compliance issues.

- 3) Based on FSP's ability to perform in accordance with BPs (and Model Contract), PVO shall discuss with USAID possible actions to take to strengthen capacity of FSPs and/or to modify the BPs, RFQ, and contract so that they are implementable, while also providing adequate safeguards.

- 4) PVO shall ensure that during fumigation, BPs are implemented by FSP, as stipulated in Annexes T-6 (Best Practices) and T-5, Model Contract, and as revised from #s 2 and 3 above.

- 5) In consultation with the FSP, PVO shall prepare Fumigation Management Plans (FMP, Annex T-3) for each fumigation event, which shall provide guidance for the fumigation process. Each FMP shall be retained for two years in project files.

6) If PVO has fumigators on staff who serve as FSPs, the above mitigation measures 2 through 5 shall be followed. In addition, applicable mitigation measures below (B through D) shall be followed.

7) The PVO shall retain the MSDS, label, and emergency/first aid measures at the warehouse office or other nearby, convenient location (See Annexes T-2, T-3 and T-7). This information shall be made available to all staff, and if required, key sections should be translated to local language.

8) Prior to fumigating, if contact pesticides are to be used, PVO shall ensure that spraying is done in accordance with USAID's Pesticide Procedures, which require that a PERSUAP is approved prior to using/procuring pesticides, and that they are used in an environmentally sound manner that reduces potential impacts to human health.

9) PVO shall ensure that phosphine fumigation is implemented within an IPM framework that involves use of non-chemical measures (see warehouse checklist, Annex T-6), and the use of pesticides as a last resort control, using least toxic (i.e., IGRs, inert dust), efficacious, cost-effective pesticides before more toxic.

10) Based on Annex T-6, Warehouse Inspection Checklist, PVO shall revise, as necessary, PVO-specific warehouse sanitation and inspection procedures.

11) PVO shall include warehouse infrastructure improvements in DFAP budget for Title II program (if allowable).

B) to minimize potential adverse impacts related to Issue 2: Use of the fumigant, phosphine, can affect the health of residents nearby to the warehouse being fumigated

1) PVO shall develop a plan for notification of nearby residents (see Annex T-6), which shall be implemented prior to conducting fumigation.

C) The quality of the food commodity may be compromised due to phosphine fumigation; beneficiary populations may be at risk from inhalation, preparation, and ingestion of fumigated commodities.

1) When procuring an FSP, PVO shall use Annex T-4 and T-5, Model RFQ and Contract (and see Annex T-6) to ensure that BPs are implemented regarding placement of aluminum/magnesium phosphide under the stack.

2) When procuring an FSP, PVO shall use Annex T-4 and T-5, Model RFQ and Contract (and see Annex T-6) to ensure FSP provides an adequate aeration period.

D) To minimize potential adverse impacts related to Issues 5, 6, & 7: Phosphine fumigation can affect water quality, soil, and non-target organisms; poor handling (transport, storage, and disposal) of fumigants could have adverse impacts on human health and the environment; and Improper disposal practices of rodents and birds, etc. killed by the fumigant, phosphine, could affect human health

1) When procuring an FSP, PVO shall use Annex T-4 and T-5, Model RFQ and Contract, to ensure that FSP implements proper transport, storage, and disposal practices, including disposal of dead rodents and birds.

- 2) PVO shall ensure that on PVO sites, fumigants are stored safely and securely to minimize potential impacts to human health and the environment; and that PVO responsibilities in regard to transport and disposal are conducted in accordance with BPs (see Annex T-6).

ADDITIONAL RECOMMENDATIONS

To strengthen capacity of PVO staff and FSPs:

- 1) PVO shall ensure that PVO staff who review quotes/proposals from FSPs are trained to evaluate technical fumigation issues.
- 2) PVO shall ensure that PVO staff who supervise/oversee warehouse fumigation are trained to monitor fumigation in accordance with Annex T-6 and the supporting Annexes, T-2 and T-8.
- 3) PVO shall ensure that at least one PVO staff is trained to inspect the warehouse post-fumigation to ensure a successful fumigation; and to identify key stored-product pests of the country/region (see below issue, resistance).
- 4) PVO shall ensure that warehouse staff are well trained in implementing warehouse sanitation procedures and inspections (see Annex T-6).
- 7) For capacity strengthening of FSPs, see Mitigation Measure A #2.

To address issues with insect resistance due to implementation of poor fumigation practices (shorter than needed fumigation periods, leaky fumigation):

- 1) In addition to measures above requiring implementation of BPs during fumigation (use of good quality tarps, airtight seals, and sufficient length of time for a fumigation event), PVO shall inspect warehouse post-fumigation and track fumigation successes and failures in ridding commodities of infestations.

MITIGATION MEASURES FOR IMPLEMENTATION BY USAID

The following mitigation measures apply to USAID/DCHA Bureau Environmental Officer and USAID/FFP offices at Missions with Title II programs.

- 1) PVO-specific PERSUAPs must be approved prior to providing assistance for the use or procurement of aluminum/magnesium phosphide. USAID shall:
 - Work with PVOs to ensure they understand the need to submit a PERSUAP for fumigation.
 - Ensure that PEA mitigation measures and BPs are incorporated into the PERSUAP.
 - Provide timely review and approval of fumigation PERSUAPs.
- 2) PEA BPs/mitigation measures may need to be modified to take into account country and project-specific situations. USAID shall:
 - Work with PVOs to develop practical BPs for the specific country and/or PVO project.
 - Ensure that modified BPs are integrated into the PVO PERSUAP.

3) The USEPA requires that only certified applicators use aluminum/magnesium phosphide, considered Restricted Use Pesticides. USAID shall:

- Collaborate with PVOs and FSPs to determine the need to support in-depth and recurrent training on proper fumigation practices (This could be provided through online services or by other means, see Annexes T-13; and could be funded through cost-sharing or other innovative means).
- Work with PVOs and FSPs to identify product stewardship programs, offered by pesticide distributors, that PVOs and FSPs could collaborate with to provide ongoing technical assistance and training.

4) Aluminum/magnesium phosphide does not control fungal contamination. The only reliable measure to protect against fungal growth is to purchase commodity that is at 13% or less moisture, and distribute it as quickly as possible so that once it arrives in the host country, moisture level has no chance to increase to 14.5% or higher, a level that promotes mold growth. USAID shall:

- Collaborate with USDA partners to ensure that purchased commodity complies with 13% of less moisture level.

5) For control of infestation and to control fungal growth

- Continue to promote “First In First Out” method of commodity management.
- Promote web-based tracking systems that can help ensure commodity moves quickly through the Title II food aid commodity chain.

6) To fill data gaps/research needs identified in the PEA, USAID/DCHA BEO shall collaborate with USAID/Washington/FFP, private sector, other US and host country government agencies, and universities to determine measures to fill the following gaps:

- Health risks to nursing mothers/infants and health risk to all beneficiaries
- Chronic health effects: The HHRE evaluated only acute health effects of phosphine
- Insect-resistant packaging: Further exploration is needed of improved packaging
- Toxicity of inert ingredients
- Use and commercialization of traditional practices, such as neem and hermetic storage: If promising, they could be promoted as potential environmentally sound, low impact means of stored-product pest management.
- No information collected by the PEA Team from nearby residential areas: Further exploration may be needed regarding potential health impacts experienced by nearby residents.

6. CONCLUSIONS AND RECOMMENDATIONS

The following are the PEA Team’s major conclusions, based on literature reviews, fieldwork, and interviews, as well as their prior experience in the field. Recommendations are also outlined.

6.1 MAJOR CONCLUSIONS

The PEA Team evaluated fumigation of Title II food aid from arrival at the receiving port to distribution centers at beneficiary communities. The PEA Team found that fumigation may take place at receiving ports, pre-positioning warehouses, and primary and secondary warehouses. Fumigation at distribution centers is rare because food aid is quickly moved out to beneficiaries, whereas at port and other warehouses along the chain, food aid commodity may remain in storage for three months or longer.

Warehouse managers and PVOs may make a decision to fumigate using both a calendar basis (every six weeks to three months) and by monitoring stored food aid to identify potential infestations. When monitoring, PVOs interviewed by the PEA Team stated that if they see a stored-product insect, they make a decision to fumigate; there is no lower threshold level. However, the PEA Team noted that warehouse workers (those conducting monitoring) were unable to identify stored-product insects.

The PEA Team identified possible shortcomings in implementation of integrated pest management (IPM) and other best practices:

- 1) Standard sanitation practices at warehouses may not be adequate: commodity may not be swept up between deliveries, when bags break open, or when commodity leaks out of stitching; pallets may not be cleaned well between deliveries; warehouses are not well lit; and flashlights may not be used during warehouse inspections (see Annex J, photos 6, 7, 18, 19, and 21).
- 2) Warehouse construction may not meet US standards: The majority of warehouses are rented, not owned by the PVOs; landlords may not agree to upgrades, and PVOs may not have funding available to make upgrades. Vents allow pests in; gaps at floor to wall junctions allow rodents and insects to enter; vents in the ceiling allow birds to enter; floors are not smooth and food gathers in the cracks, providing a regular source of food for insects and rodents (see Annex J, photos 2, 3, 8, 9, 15, and 20).
- 3) Trucks may not be cleaned well between deliveries and loading.
- 4) Personal protective equipment (PPE) may not be used, or may be used and maintained incorrectly: Issues with PPE include use of masks with expired canisters, use of canisters that are not meant for phosphine fumigation, and use of dust masks by fumigators (see Annex J, photo 12).
- 5) Food aid bags allow considerable leakage during transport and storage at warehouses. The seams on the bags may be only single seams with gaps in stitching, from which commodity easily leaks and where insects can easily enter. The material of the food aid bag—because of the stacking and the pressure created on the lower bags in the stack—has gaps that expand and allow leakage and insect entry (see Annex J, photos 4, 5, 6, 16, and 17).
- 6) Because of the hot, tropical climate, warehouse doors may be left open during the day to allow for ventilation. This also allows birds and rodents to enter. In the U.S. warehouse doors are always closed; however, in tropical climates, that may not be practical (see Annex J, photos 2 and 9).

- 7) Regular training in fumigation, including IPM, may be unavailable to those in charge of conducting and monitoring fumigation.
- 8) Prior to and/or after fumigating, contact pesticides (i.e., pirimiphos methyl formulated as an Emulsifiable Concentrate—or EC) may be applied to an empty warehouse walls, pallets or to floor surfaces between and outside stacks.
- 9) Fumigators may not possess phosphine meters or be monitoring phosphine gas concentrations under enclosures to determine effectiveness neither against insects, nor outside the sheets for worker and bystander safety. Yet, monitoring is a quintessential part of fumigation, and is the only way successful and safe fumigation can be ensured.
- 10) Fumigation usually lasts for three to seven days including placement of tarpaulins and fumigant, aeration, and removal of tarps; this may be too short to ensure successful fumigation and to control resistant strains of insects. Short fumigations predispose insects to develop resistance.
- 11) Stacks in a warehouse are enclosed with plastic or tarps. Warehouse doors and vents, however, may not be sealed during fumigation. Because of the gaps, gas can leak from the warehouse. In addition, fumigation tarps may be re-used too often, may weaken and get torn, and therefore, would not create a gas tight seal. The warehouse compound may remain open during fumigation, potentially exposing workers in adjacent warehouses, office workers, and others working on-site to phosphine gas. Placarding may be inadequate to ensure that no entry will occur; warning signs may not have sufficient information about emergency procedures.
- 12) Fumigants may not be transported and stored under secure and environmentally sound conditions; phosphine residues may not be disposed of in accordance with labeling requirements.

The PEA Team reviewed existing international fumigation guidance, including those published by USAID and PVOs. The USAID Commodity Reference Guide (CRG)⁴ has generic information on pest management. The WFP has a standard operating procedure (SOP) for contracted fumigation that outlines site preparation, use of aluminum phosphide tablets/pellets, phosphine gas monitoring, placarding, clearing (aeration), disposal of spent phosphine tablet residues, and spraying warehouses with residual chemicals after fumigation. Many PVOs have developed commodity management guides, which address pest management, as well as other aspects of commodity management. The technical quality of the guidance varies. Most of the guidance documents have shortcomings; for example, training information, insect resistance, and phosphine gas monitoring are often briefly or not at all covered.

In the US, and in accordance with labeling, a Fumigation Management Plan (FMP) is required prior to fumigation. The FMP summarizes the steps that will be taken before, during, and after the fumigation. It helps ensure that the fumigant is applied effectively and safely. From USAID and PVO guidance and procedures that the PEA Team reviewed, and from those interviewed, an FMP, a critical part of fumigation and a label requirement, is not typically part of the Title II food aid fumigation process.

⁴CRG Section IV: Controlling damage to food commodities http://www.usaid.gov/our_work/humanitarian_assistance/ffp/crg/sec4.htm

While best practices and standards for fumigation are typically followed in the US, as described above, the PEA Team found that once food aid arrives at the host country port, fumigation guidance may be inadequate, knowledge and training of applicators and supervisors is highly variable and may be outdated, and best practices for fumigation are inconsistently applied. Development and implementation of standard procedures for safe and effective fumigation and non-fumigation based IPM practices are essential for prevention and management of insects associated with food aid commodities in the receiving countries.

Fumigation with aluminum/magnesium phosphide is an integral part of managing pests of stored-product commodities. If fumigation is conducted without implementation of best practices, negative human health impacts may result; environmental impacts, although of concern, are less likely and less likely to be significant than the potential impacts to human health. Safeguards are available and can be implemented by USAID Food for Peace (FFP) offices, Title II PVOs, and their partners to minimize potential impacts to fumigators, warehouse workers and visitors, and nearby residents. Section 5 of this PEA includes an analysis of the potential significant impacts, as identified in the Scoping Statement and revised by the PEA Team, and briefly describes mitigation measures to minimize potential impacts.

6.2 DATA GAPS

While the toxicity of phosphine gas and its precursors, aluminum and magnesium phosphide, have been well-studied, data gaps remain in evaluating sensitive subpopulations and potential risks in the context of food aid for developing countries, as follows:

1) Health risks to nursing mothers/infants: Pregnant and nursing mothers may ingest food that has been fumigated prior to reaching their households. As a potentially sensitive subpopulation, there is concern that mothers could pass phosphine and/or its breakdown products to their unborn or nursing children. Although phosphine is not considered to be bioaccumulative, inadequate information is available to properly evaluate the exposure, fate, clearance, and transfer of chronic to subchronic levels of phosphine gas in these populations from gas adsorbed into food commodities following fumigation. There is also no information available on the sensitivity of women and infants to low levels of phosphine gas.

Phosphine de-gasses quickly once aeration begins; it is unlikely that ingesting food that has been fumigated could impact human health. However, data are insufficient to confidently determine the potential for risk.

2) Health risk to all beneficiaries: A thorough evaluation is needed of the kinetics of phosphine desorption and residue transformation in and on the surface of food commodities to determine exposure and evaluate risk to beneficiaries. Measuring and predicting these residue levels is confounded by variables such as temperature, concentration and duration of fumigation, duration of aeration, type of commodity, and type of bagging, which can result in substantially different concentrations of phosphine once they reach the beneficiary level. Additionally, a realistic model for chronic exposure is impossible to formulate, as food aid is an intermittent exposure pathway with a high degree of unpredictability. It will be difficult to impossible to provide a data set that adequately surveys the range of beneficiaries.

Because phosphine de-gasses quickly from food commodities, and little if any phosphine remains adsorbed to food (see Section 5 of the PEA for research conducted to date), this route of exposure is unlikely to lead to a potential human health impact. However, to confidently state that no potential impact to the health of Title II beneficiaries is possible, additional studies are needed.

3) Chronic health effects: The HHRE evaluated only acute health effects of phosphine. In addition to information on the health risk to beneficiaries discussed above, research is needed on the potential chronic health impacts to fumigators, other on-site workers, and nearby residents. This is of special concern since fumigators in Title II countries, use required other on-site workers (present in the warehouse compound during fumigations) and nearby residents are unlikely to have, properly maintain or use PPE. The current US standards (Occupational Safety and Health Administration, OSHA, and US Environmental Protection Agency, USEPA) may not apply in Title II cases. For example, occupational standards are applicable only to those workers who are trained in the use of specific chemicals. Fumigation may affect other persons (bystanders, nearby residents, etc.) who are not aware of the risks of these chemicals and who may, unlike the trained workers, be in worse health, much younger or older, and/or exposed for durations that exceed typical worker exposure scenarios of 8 hours/day, five days/week.

4) Insect-resistant packaging: Further exploration is needed of improved packaging. A number of new sealing techniques, odor barriers, alternative natural fumigants, and multi-walled types of bags are now available that could be explored further. These alternative measures could make packages insect resistant and decrease the quantities of pesticides and fumigants needed.

5) Toxicity of inert ingredients: Pesticides are formulated with active and inert ingredients. Aluminum phosphide tablets are commonly formulated at 55-60% active ingredient (AI) along with ammonium carbonate and inert ingredients related to the effectiveness against pests. However, many inert ingredients are not chemically, biologically, or toxicologically inert to other receptors. Generally, inert ingredients are minimally tested for potential adverse health and environmental impacts, although many are hazardous to human health.

6) Residues from application of grain protectants in the US: The PEA Team did not evaluate the presence of residues on commodities due to application of grain protectants on farms in the US. Detectable amounts of these residues may be found in both raw and processed commodities. The U.S. Department of Agriculture's (USDA) Pesticide Data Program maintains an online database of commodities tested for multiple pesticide residues. In most cases, residue levels on commodities are well below the established tolerance levels. However, because the PEA focused on fumigation from host country port to beneficiary community, the PEA Team did not explore potential impacts of pesticides used in the US and residue levels in raw and processed commodities.

7) Use and commercialization of traditional practices, such as neem and hermetic storage: Some traditional practices have potential to be scaled up and used in Title II warehouses as an alternative, or partial alternative to fumigation. However, information is insufficient as to the potential for scale-up and efficacy. Traditional measures should be further explored, and if promising, could be promoted as potential environmentally sound, low impact means of stored-product pest management.

8) No information collected from nearby residential areas: The PEA Team visited warehouses in Uganda, Ethiopia, and Djibouti; however, none were located near residential areas. Further exploration may be needed regarding potential health impacts experienced by nearby residents. This remains an information gap.

9) No information from companies that train and certify personnel in fumigation in Title II countries: The PEA Team was unable to meet with companies in Uganda, Ethiopia, or Djibouti that train personnel in fumigation. The PEA Team overcame this information gap by interviewing fumigation service providers.

REFERENCES

- Adler, C., H-G. Corinth, and C. Reichmuth. 2000. Modified Atmospheres, pp. 105-146. In *Alternatives to Pesticide in Stored-Product IPM*, Subramanyam, Bh., and D. W. Hagstrum (ed.), Kluwer Academic Publishers, Boston, Massachusetts.
- Alam, M., M. Ahmed, M. Hasanuzzaman, and M. O. Islam. 2009. Seed Quality of Aman Rice as Affected by Some Alternate Storage Devices. *American-Eurasian J. Agronomy* 2: 130-137.
- Alavanja, M. C., J. A. Hoppin, and F. Kamel. 2004. Health Effects of Chronic Pesticide Exposure: Cancer and Neurotoxicity. *Annual Review of Public Health* 25: 155-197.
- Amoore, J.E., and E. Hautala. 1983. Odor as an Aid to Chemical Safety: Odor Thresholds Compared with Threshold Limit Values and Volatilities for 214 Industrial Chemicals in Air and Water Dilution. *Journal of Applied Toxicology* 3: 272-290.
- Anonymous. 1989. Suggested Recommendations for the Fumigation of Grain in the ASEAN Region. Part 1. Principles and General Practice. ASEAN Food Handling Bureau, Kuala Lumpur and Australian Center for International Agricultural Research, Canberra, Published by Media Works Enterprise, 131 pages.
- Anonymous. 1999. Pesticide Fact Sheet, Phosphine Conditional Registration, USEPA, Office of Prevention, Pesticides, and Toxic Substances December, 1999 (7505C)), Washington, D. C.
- Anonymous. 2010. Impacts on the US Economy of Shipping International Food Aid. A Report Prepared for USA Maritime. Promar International, Alexandria, Virginia, 22 pages.
- Antonacci, L., A. E. Salvat, G. C. Faifer, and H. M. Godoy. 1999. Suppression of Spore Germination and Aflatoxin Biosynthesis in *Aspergillus parasiticus* During and After Exposure to High Levels of Phosphine. *Mycopathologia* 147: 83-87.
- Arthur, F. H. 1998. Effects of Flour Food Source on Red Flour Beetle (Coleoptera: Tenebrionidae) Survival After Exposure on Concrete Treated with Cyfluthrin. *Journal of Economic Entomology* 91: 773-778.
- Arthur, F. H., and J. F. Campbell. 2008. Distribution and Efficacy of Pyrethrin Aerosol to Control *Tribolium confusum* (Coleoptera: Tenebrionidae) in Food Storage Facilities. *Journal of Stored Products Research* 44: 58-64.
- Arthur, F. H., and P. S. Peckman. 2006. Insect Management with Residual Insecticides, pp. 167-173. In Heaps, J. W. (ed.), *Insect Management for Food Storage and Processing*, Second Edition. American Association of Cereal Chemists International, St. Paul, Minnesota.
- Agency for Toxic Substances and Disease Registry (ATSDR). 2004. Toxicological Profile for Ammonia. Available on the Internet at: <http://www.atsdr.cdc.gov/toxprofiles/tp126.pdf>
- Agency for Toxic Substances and Disease Registry (ATSDR). 2011. Medical Management Guidelines for Phosphine. Available on the Internet at: <http://www.atsdr.cdc.gov/mmg/mmg.asp?id=1013&tid=214>

- Bailey, S. W., and H. J. Banks. 1975. The Use of Controlled Atmospheres for Storage of Grain, pp. 362-374. In *Proceedings of the 1st International Conference on Stored-Product Protection*, Savannah, Georgia.
- Banks, H. J. 1981. Effects of Controlled Atmospheric Storage on Grain Quality: A Review. *Food Technology in Australia* 33: 335-340.
- Banks, H. J., and P. C. Annis. 1980. Conversion of Existing Grain Storage Structures for Modified Atmosphere Use, pp. 461-473. In *Proceedings of the International Symposium on Controlled Atmosphere Storage of Grains*, Shejbal, J. (ed.). Elsevier Scientific Publishing Company, New York.
- Banks, H. J., and P. G. Fields. 1995. Physical Methods for Insect Control in Stored-Grain Ecosystems, pp. 353-410. In *Stored-Grain Ecosystems*, Jayas, D. S., N. D. G. White, and W. E. Muir (ed.), Marcel Dekker, New York.
- Barbosa, A., and A. M. Bonin. 1994. Evaluation of Phosphine Genotoxicity at Occupational Levels of Exposure in New South Wales, Australia. *Occupational and Environmental Medicine* 51: 700-705.
- Beckett, S. J., P. G. Fields, and Bh. Subramanyam. 2007. Disinfestation of Stored Products and Associated Structures Using Heat, pp. 182-236. In Tang, J., E. Mitcham, S. Wang, and S. Lurie (ed.), *Heat Treatments for Postharvest Pest Control: Theory and Practice*. CAB International, Oxon, United Kingdom.
- Bell, C. H. 1996. Alternatives-Physical Methods and Emission Reduction, pp. 323-389. In *The Methyl Bromide Issue*, Bell, C. H., N. Price, and B. Chakrabarti (ed.), *Agrochemicals and Plant Protection*, Volume 1, John Wiley & Sons, New York.
- Bell, C. H. 2006. Factors Affecting the Efficacy of Sulfuryl Fluoride as a Fumigant, pp. 519 – 526. In *Proceedings of the 9th International Working Conference on Stored Product Protection*, Lorini, I., B. Bacaltchuk, H. Beckel, D. Deckers, E. Sundfeld, J. P. dos Santos, J. D. Biagi, J. C. Celaro, L. R. D'A. Faroni, L. de O. F. Bortolini, M. R. Sartori, M. C. Elias, R. N. C. Guedes, R. G. da Fonseca, and V. M. Scussel (ed.), October 15-18, 2006, Campinas, Brazil. Brazilian Post-harvest Association, Campinas, Brazil.
- Bell, C. H., and N. Savvidou. 1998. The Toxicity of Vikane® (Sulfuryl Fluoride) to Age Groups of Eggs of the Mediterranean Flour Moth (*Ephestia kuehniella*). *Journal of Stored Products Research* 35: 233-247.
- Berck, B. 1968. Sorption of Phosphine by Cereal Products. *Journal of Agricultural and Food Chemistry* 16: 419-425.
- Bhatt, M. H., M. A. Elias, and A. K. Mankodi. 1999. Acute and Reversible Parkinsonism Due to Organophosphate Pesticide Intoxication: Five Cases. *Neurology* 52: 1467-1471.
- Bloomquist, J. R. 1996. Ion Channels as Targets for Insecticides. *Annual Review of Entomology* 41: 163-190.
- Boina, D. R., and Bh. Subramanyam. 2011. Insect Management with Aerosols in Food-Processing Facilities, pp. 195-212. In *Insecticides: Advances in Integrated Pest Management*, Perveen, F. (ed.), Intech-Open Access Publisher (<http://www.intechopen.com/books/insecticides-advances-in-integrated-pest-management/insect-management-with-aerosols-in-food-processing-facilities>).

- Bond, E. J., J. R. Robinson, and C. T. Buckland. 1969. The Toxic Action of Phosphine: Absorption and Symptoms of Poisoning in Insects. *Journal of Stored Products Research* 5: 289-298.
- Brijwani, M., Bh. Subramanyam, P. W. Flinn, M. R. Langemeier, M. Hartzer, and R. Hulasare. 2012. Susceptibility of *Tribolium castaneum* Life Stages Exposed to Elevated Temperatures During Heat Treatments of a Pilot Flour Mill: Influence of Sanitation, Temperatures Attained Among Mill Floors, and Costs. *Journal of Economic Entomology* 105: 709-717.
- Cáceres, T., M. Meghraj, K. Venkateshwarlu, N. Sethunathan, and R. Naidu. 2010. Fenamiphos and Related Organophosphorus Pesticides: Environmental Fate and Toxicology. *Review of Environmental Contamination and Toxicology* 205: 117-162.
- Calderon, M., and S. Navarro. 1979. Increased Toxicity of Low Oxygen Atmospheres Supplemented with Carbon Dioxide on *Tribolium castaneum* Adults. *Entomologia Experimentalis et Applicata* 25: 39-44.
- Castro, M. F. P. M., and I. A. de Pacheco. 1995. Utilization of Phosphine Fumigant for the Control of Fungi Naturally Present in Stored Paddy Rice (*Oryza sativa* L.). *Revista de Microbiologia* 26: 230-235.
- Castro, M. F. P. M., I. A. de Pacheco, and M. H. Taniwaki. 1992. Effects of Phosphine on Aflatoxin Production in Peanuts Stored with a High Moisture Content. In *Methyl Bromide Technical Options Workshop*, Washington, D. C.
- Castro, M. F. P. M., M. F. F. Leitao, J. O. do Vale, N. Bragnolo, E. S. Anichiareo, and K. A. Mills. 2000. Effects of Phosphine in the Development of *Aspergillus flavus* Aflatoxin Production in Maize Grains Stored at Different Moisture Contents, pp. 171-191. In *Proceedings of the International Working Conference on Controlled Atmosphere and Fumigation in Stored Products*, Donahaye, E. J., S. Navarro, and J. G. Leesch (ed.), 29 October – 3 November 2000, Fresno, CA. Executive Printing Services, Clovis, California.
- CATAMA. 1953. *Aviation Toxicology—An Introduction to the Subject and a Handbook of Data*. Committee on Aviation Toxicology, Aero Medical Association, The Blakiston Co., New York, New York.
- CCOHS. 1990. Carbon Dioxide Chemical Infogram. Canadian Center for Occupational Health and Safety, Hamilton, Ontario. <http://www.epa.gov/ozone/snap/fire/co2/appendixb.pdf>.
- Checkoway, H., N. J. Heyer, P. A. Demers, and N. E. Breslow. 1993. Mortality Among Workers in the Diatomaceous Earth Industry. *British Journal of Industrial Medicine* 50: 586-597.
- Cline, L. D. and H. A. Highland 1981. Minimum Size of Holes Allowing Passage of Adults of Stored Product Coleoptera. *Journal of Georgia Entomological Society* 16: 525-531.
- Chayaprasert, W., D. E. Maier, Bh. Subramanyam, and M. Hartzer. 2012. Gas Leakage and Distribution Characteristics of Methyl Bromide and Sulfuryl Fluoride During Fumigations in a Pilot Flour Mill. *Journal of Stored Products Research* 50: 1-7.
- Clark, J. M. 1974. The Toxicity of Oxygen. *American Review of Respiratory Disease* 110: 40–50.
- Corrigan, R. M. 2001. *Rodent Control: A Practical Guide for Pest Management Professionals*. Published by GIE Media, Cleveland, Ohio.

- Cox, C. 1994. Chlorpyrifos. Part I. *Journal of Pesticide Reform* 14: 15-19.
- Cryer, S. A. 2008. Predicted Gas Loss of Sulfuryl Fluoride and Methyl Bromide During Structural Fumigation. *Journal of Stored Products Research* 44: 1-10.
- Csondes, A. 2004. Environmental date of Methoprene. Department of Pesticide Regulations Sacramento, California. Available at <http://www.cdpr.ca.gov/docs/emon/pubs/methofate.pdf>.
- Danley, R., B. D. Adam, J. Criswell, R. Noyes, and T. W. Phillips. 2005. How Accurate are Phosphine Monitoring Devices? *Journal of Pesticide Safety Education* 7: 1-9.
- Degesch America, Inc. 2010. Material Safety Data Sheet for Magnesium Phosphide, Weyers Cave, VA. November 2010. Available on the Internet at: <http://www.degeschamerica.com/docs/MSDS/Mg3P2%20MSDS.pdf>.
- Degesch America, Inc. 2011. Material Safety Data Sheet for Aluminum Phosphide, Weyers Cave, VA. April 2011. Available on the Internet at: <http://www.degeschamerica.com/docs/MSDS/AlP%20MSDS.pdf>.
- De Lima C. P. F. 1990. Airtight Storage: Principle and Practice, pp. 9-19. In *Food Preservation by Modified Atmospheres*, Calderon, M., and R. Barkai-Golan (ed.), CRC Press, Boca Raton, Florida.
- Dogan, H., Bh. Subramanyam, and J. R. Pedersen. 2010. Analysis for Extraneous Matter, pp. 351-365. In Nielsen, S. S. (ed.), *Food Analysis*, Fourth Edition. Springer, New York.
- Dosland, O., Bh. Subramanyam, G. Sheppard, and R. Mahroof. 2006. Temperature Modification for Insect Control, pp. 89-103. In, Heaps, J. (ed.), *Insect Management for Food Storage and Processing*. Second Edition, American Association of Cereal Chemists, St. Paul, Minnesota.
- Dumas, T. 1980. Phosphine Sorption and Desorption by Stored Wheat and Corn. *Journal of Agricultural and Food Chemistry* 28: 337-339.
- Eddleston M., N. A. Buckley, P. Eyer, and A. H. Dawson. 2008. Management of Acute Organophosphorus Pesticide Poisoning. *Lancet* 371: 597-607.
- Eskenazi, B., and N. A. Maizlish. 1988. Effects of Occupational Exposure to Chemicals on Neurobehavioral Functioning, pp. 242-243. In *Medical Neuropsychology: The Impact of Disease on Behavior*, Tarter, R. E., D. H. V. Thiel, and K. L. Edwards (ed.), Plenum Press, New York.
- Extension Toxicology Network (ETN). 1994. Pyrethroids. Pesticide Information Profiles. <http://ace.orst.edu/cgi-bin/mfs/01/pips/pyrethri.htm>.
- Extension Toxicology Network (ETN). 1996. Cypermethrin. Pesticide Information Profiles. <http://ace.orst.edu/cgi-bin/mfs/01/pips/cypermeth.htm>.
- Extension Toxicology Network (ETN). 1995. Deltamethrin. Pesticide Information Profiles. <http://ace.orst.edu/cgi-bin/mfs/01/pips/deltamet.htm>.
- Fields, P. G. 1992. The Control of Stored-Product Insects and Mites with Extreme Temperatures. *Journal of Stored Products Research* 28: 89-118.

Food and Agriculture Organization (FAO). 1984. Manual of fumigation for insect control (FAO Agricultural Studies No. 79, FAO Plant Production and Protection Series No. 20).
<http://www.fao.org/docrep/x5042e/x5042E00.htm>

Food and Agriculture Organization (FAO). 2012. Corporate Document Repository 1997. Agriculture, Food and Nutrition for Africa: A Resource Book for Teachers of Agriculture. Retrieved March 6, 2012, from <http://www.fao.org/docrep/w0078e/w0078e07.htm#TopOfPage>.

Food for Peace (FFP). 2006. Commodities Guide List of Cooperating Sponsors. Retrieved May 8, 2012, from http://www.usaid.gov/our_work/humanitarian_assistance/ffp/crg/sponsors.htm.

Food for Peace (FFP). 2009. What is Food for Peace? Retrieved January 12, 2012, from http://www.usaid.gov/our_work/humanitarian_assistance/ffp/index.html.

Food for Peace 2010

Food for Peace (FFP). 2011. Our Partners. Retrieved January 12, 2012, from http://www.usaid.gov/our_work/humanitarian_assistance/ffp/partners.html.

Food for Peace (FFP). 2012. How Title II Food Aid Works. Retrieved January 12, 2012, from http://www.usaid.gov/our_work/humanitarian_assistance/ffp/foodtitle2faw.03.27.12.pdf.

Fowler, B, K. N. Ackles, and G. Porlier. 1985. Effects of Inert Gas Narcosis on Behavior—A Critical Review. *Undersea Biomedical Research* 12: 369–402.

Fukuto, T. R. 1990. Mechanism of Action of Organophosphorous and Carbamate Insecticides. *Environmental Health Perspectives* 87: 245-254.

Gard News. 2011. Fumigation of Cargo on Board Ships: The Invisible Killer. December 2011.

Garey, J., and M. Wolff. 1998. Estrogenic and Antiprogestagenic Activities of Pyrethroid Insecticides. *Biochemical and Biophysical Research Communications* 251: 855-859

Garry, V. F., J. Griffith, T. J. Danzl, R. L. Nelson, E. Whorton, L. A. Krueger, and J. Cervenka. 1989. Human Genotoxicity: Pesticide Application and Phosphine. *Science* 246: 251-255.

Garry, V. F., T. J. Danzl, R. Tarone, J. Griffith, J. Cervenka, L. Krueger, E. B. Whorton, Jr., and R. L. Nelson. 1992. Chromosome Rearrangements in Fumigant Applicators: Possible Relationship to Non-Hodgkin's Lymphoma Risk. *Cancer Epidemiology, Biomarkers, and Prevention* 1: 287-291.

Garry, V. F., M. E. Harkins, L. L. Erickson, L. K. Long-Simpson, S. E. Holland, and B. L. Burroughs. 2002. Birth Defects, Season of Conception, and Sex of Children Born to Pesticide Applicators Living in the Red River Valley of Minnesota, USA. *Environmental Health Perspectives* 110: 441-449.

Gatehouse, A. M. R., and J. A. Gatehouse. 1998. Identifying Proteins with Insecticidal Activity: Use of Encoding Genes to Produce Insect-Resistant Transgenic Crops. *Pesticide Science* 52: 165-175.

Gellhorn, E., and I. Spiesman. 1934. Influence of Variations of O₂ and Carbon Dioxide Tension in Inspired Air Upon Hearing. *Proceedings of the Society of Experimental Biology and Medicine* 32: 46-47.

- Gellhorn, E., and I. Spiesman. 1935. Influence of Hyperpnea and of Variations of O₂- and CO₂-Tension in the Inspired Air Upon Hearing. *American Journal of Physiology* 112: 519-528.
- Glare, T. R., and M. O'Callaghan. 1999. Report for the New Zealand Ministry of Health: Environmental and Health Impacts of the Insect Juvenile Hormone Analogue, S-Methoprene. Biocontrol and Biodiversity, Grasslands Division, Agricultural Research, Lincoln, New Zealand.
- Global Issues. 2007. Food Aid. Retrieved May 18, 2012, from <http://www.globalissues.org/article/748/food-aid#Themajorplayersinthefoodaidgame>.
- Go, V. J. Garey, M. S. Wolff, and B. G. Pogo. 1999. Estrogenic Potential of Certain Pyrethroid Compounds in the MCF-7 Human Breast Carcinoma Cell Line. *Environmental Health Perspectives* 107: 173-177.
- Goldsmith, D. F., J. S. Gift, and L. D. Grant. (ed.). 1997. Silica Risk Assessment. *Journal of Experimental and Analytical Environmental Epidemiology* 7: 265-395.
- Goldsmith, D. F., G. R. Wagner, U. Saffioti, J. Rabovsky, and J. Leigh (ed.). 1995. Second International Symposium on Silica, Silicosis, and Cancer. *Scandinavian Journal of Work and Environmental Health* 21: Supplement 2, 120 pages.
- Good, N. E. 1937. Insects found in the milling streams of flour mills in the southwestern milling area. *Journal of the Kansas Entomological Society* 10: 135-148.
- Gosselin, R.E. 1984. *Clinical Toxicology of Commercial Products*. Williams and Wilkins. Baltimore, Maryland.
- Gould, W. A. 1994. *cGMPs/Food Plant Sanitation*, Second Edition. CTI Publications, Inc, Timonium, Massachusetts.
- Hagstrum, D. W. and Bh. Subramanyam. 2006. *Fundamentals of Stored-Product Entomology*. American Association of Cereal Chemists, St. Paul, Minnesota.
- Hagstrum, D. W., and Bh. Subramanyam. 2009. *Stored Product Insect Resource*. American Association of Cereal Chemists, St. Paul, Minnesota.
- Hale, H., and W. Franciscovich, W. (ed). 1999. *Commodity Management Enhancement Project-Food Aid Logistics Operational Handbook*. CARE, USA.
- Halverson, S. L., and S. V. Nablo. 2000. Radiation, pp. 381-400. In *Alternatives to Pesticide In Stored-Product IPM*, Subramanyam, Bh., and D. W. Hagstrum (ed.). Kluwer Academic Publishers, Boston, Massachusetts.
- Halverson, S. L., R. Plarre, W. E. Burkholder, T. S. Bigelow, J. H. Booske, and M. E. Misenheimer. 1997. Recent Advances in the Control of Insects in Stored Products with Microwaves. *American Society of Agricultural Engineers (ASAE) Paper No. 976098*. ASAE Annual International Meeting, August 10 – 14, 1997, Minneapolis Minnesota.
- Hocking, A. D., and H. J. Banks. 1991a. Effects of Phosphine Fumigation on Survival and Growth of Storage Fungi in Wheat. *Journal of Stored Products Research* 41: 232.

- Hocking, A. D., and H. J. Banks. 1991b. Effects of Phosphine Fumigation on the Development of Storage Mycoflora in Paddy Rice, pp. 823-831. In Proceedings of the 5th International Working Conference on Stored-Product Protection, Fluerat-Lessard, F., and P. Ducom (ed.). INRA, Bordeaux, France.
- Huang, F., and Bh. Subramanyam. 2005. Management of Five Stored-Product Insects in Wheat with Pirimiphos-methyl and Pirimiphos-methyl Plus Synergized Pyrethrins. *Pest Management Science* 60: 191-198.
- Hyde, M. B., A. A. Baker, A. C. Ross, and C. O. Lopez. 1973. Airtight Gas Storage. *FAO Agricultural Service Bulletin* 17: 71.
- Imholte, T. J. and T. K. Imholte-Tauscher. 1999. *Engineering for Food Safety and Sanitation*, Second Edition. Technical Institute for Food Safety, Woodinville Press, Washington.
- Jay, E. G., R. T. Arbogast, and G. C. Pearman, Jr. 1971. Relative Humidity and its Importance in the Control of Stored Product Insects with Modified Atmospheric Gas Concentrations. *Journal of Stored Products Research* 6: 325-329.
- Jayas, D. S., and S. Jeyamkondan. 2002. Modified Atmosphere Storage of Grains, Meats, Fruits, and Vegetables. *Biosystems Engineering* 82: 235-251.
- Johnson, D. L. 1990. Influence of Temperature on Toxicity of Two Pyrethroids to Grasshoppers (Arthropoda: Acrididae). *Journal of Economic Entomology* 83: 431-436.
- Kenkel, P., J. T. Criswell, G. Cuperus, R. T. Noyes, K. Anderson, W. S. Fargo, K. Shelton, W. P. Morrison, and B. Adam. 1993. Current Management Practices and Impact of Pesticide Loss in the Hard Red Wheat Postharvest System. Oklahoma Cooperative Extension Service, Cir. E-930, Oklahoma State University, Stillwater, Oklahoma.
- Khair, A. and K. M. Safeeulla. 1994. Effect of Fumigation on Seed Viability, Seedling Vigour, Seedborne Mycoflora and Insects in Paddy [in India]. *Bangladesh Journal of Life Sciences* 6: 79-84.
- Khamis, M., Bh. Subramanyam, H. Dogan, P. W. Flinn, and J. A. Gwartz. 2011. Effects of Flameless Catalytic Infrared Radiation on *Sitophilus oryzae* (L.) Life Stages. *Journal of Stored Products Research* 47: 173-178.
- Kligerman, A., M. Bryant, C. Doers, et al. 1994a. Cytogenetic Effects of Phosphine Inhalation by Rodents. I: Acute 6-hour Exposure of Mice. *Environmental and Molecular Mutagenesis* 23: 186-189. (As cited in USEPA, 1998).
- Kligerman, A., J. Bishop, G. Erexson, et al. 1994b. Cytogenetic and Germ Cell Effects of Phosphine Inhalation by Rodents II: Subacute Exposures to Rats and Mice. Unpublished study prepared by National Institute of Environmental Health Science Inhalation Facility, United States Environmental Protection Agency, Washington, D. C., 28 pages. (As cited in USEPA, 1998).
- Korunic, Z., P. G. Fields, M. I. P. Kovacs, J. S. Noll, O. M. Lukow, C. J. Demianyk, and K. J. Shibley. 1996. The Effect of Diatomaceous Earth on Grain Quality. *Postharvest Biology and Technology* 9: 373-387.
- Krishnamurthy, T. S., E. C. Spratt, and C. H. Bell. 1986. The Toxicity of Carbon Dioxide to Adult Beetles in Low Oxygen Atmospheres. *Journal of Stored Products Research* 22: 145-151.

Larson, Z., Bh. Subramanyam, and T. Herrman. 2008. Stored-Product Insects Associated with Eight Feed Mills in the Midwestern United States. *Journal of Economic Entomology* 101: 998-1005.

Le Torc'h, J. M., and F. Fluerat-Lessard. 1991. The Effects of High Pressure on Insecticide Efficacy of Modified Atmospheres Against *Sitophilus granarius* (L.) and *S. oryzae* (L.) (Coleoptera: Curculionidae), pp. 847-856. In *Proceedings of the 5th International Working Conference on Stored Product Protection*, Fluerat-Lessard, F., and P. Ducom (ed.), INRA, Bordeaux, France.

Locatelli, D. P., and E. Daolio. 1993. Effectiveness of Carbon Dioxide Under Reduced Pressure Against Some Insects Infesting Packaged Rice. *Journal of Stored Products Research* 29: 81-87.

Mamadaliyev S. M., Z. K. Koshemetov, V. M., Matveyeva, Z. K. Kydyrbayev Z. K.1, V. L. Zaitsev, B. M. Khairullin, M. A. Mambetaliyev, N. T. Sandybayev, S. S. Nurabayev, A. Z. Azhibayev, Y. A. Bulatov, B. S. Katubayeva, Y. M. Kozhamkulov, K. K. Tabynov, A. I. Kydyrmanov, K. D. Daulbayeva, and L. I. Shahvorostova. 2007. Avian Influenza Virus H5N1 Subtype A Diagnosed in Sick and Dead Wild and Domestic Birds in Pavlodar Oblast, Republic of Kazakhstan. *African Journal of Agricultural Research* 2: 360-365.

Mansdorf, S.; T. Knupp, M. Bold. 1988. Phosphine Exposure Monitoring for Applicators, Workers, and Nearby Persons. Unpublished study prepared by S.Z. Mansdorf & Associates. 1180 p. As cited in USEPA, 1998.

Matthews, R. H., C. C. Fifield, and T. F. Hartsing. 1970. Effects of Fumigation on Wheat in Storage, II. Physical and Eating Qualities of Bread and Rolls. *Cereal Chemistry* 47: 587-591. (As cited in Plimmer, 1977).

McGregor, H. E. and K. J. Kramer. 1975. Activity of Insect Growth Regulators, Hydroprene and Methoprene, on Wheat and Corn Against Several Stored-Grain Insects. *Journal of Economic Entomology* 68: 668-670.

Memis, D., D. Tokatlioglu, O. Koyuncu, and S. Hekimoglu. 2007. Fatal Aluminum Phosphide Poisoning. *European Journal of Anaesthesiology* 24: 292-293.

Menegon, A., P. G. Board, A. C. Blackburn, G. D. Mellick, and D. G. Le Couteur. 1998. Parkinson's disease, pesticides, and glutathione transferase polymorphisms. *Lancet* 352: 1344-1346.

Miyamoto, J. 1976. Degradation, Metabolism and Toxicity of Synthetic Pyrethroids. *Environmental Health Perspectives* 14: 15-28.

Mueller-Beilschmidt, D. 1990. Toxicology and Environmental Fate of Synthetic Pyrethroids. *Journal of Pesticide Reform* 10: 32-37.

Misra, U. K., S. K. Bhargava, D. Nag, M. M. Kidwai, and M. M. Lal. 1988. Occupational Phosphine Exposure in Indian Workers. *Toxicology Letters* 42: 257-63.

Mitcham, E., T. Martin, and S. Zhou. 2006. The Mode of Action of Insecticidal Controlled Atmospheres. *Bulletin of Entomological Research* 96: 213-222.

Moussa, B., J. Lowenberg-DeBoer, J. Fulton, and K. Boys. The Economic Impact of Cowpea Research in West and Central Africa: A Regional Impact Assessment of Improved Cowpea Storage Technologies. *Journal of Stored Products Research* 47: 147-156.

- Mowery, S. V., M. A. Mullen, J. F. Campbell, and A. B. Broce. 2002. Mechanism Underlying Sawtoothed Grain Beetle (*Oryzaephilus surinamensis* [L.]) (Coleoptera: Silvanidae) Infestation of Consumer Food Packaging. *Journal of Economic Entomology* 95: 1333-1336.
- Mullen, M. A. and S. V. Mowery. 2006. Insect-Resistant Packaging, pp. 35-51. In *Insect Management for Food Storage and Processing*, Heaps, J. W. (ed.), American Association of Cereal Chemists, St. Paul, Minnesota.
- Mullen, M. A. and J. R. Pedersen. 2000. Sanitation and Exclusion, pp. 29-50. In *Alternatives to Pesticides in Stored-Product IPM*, Subramanyam, Bh., and D. W. Hagstrum (ed.). Kluwer Academic Publishers, Massachusetts.
- Murdock, L. L., D. Seck, G. Ntougam, L. Kitch, and R. E. Shade. 2003. Preservation of Cowpea Grain in Sub-Saharan Africa-Bean/Cowpea CRSP Contributions. *Field Crops Research* 82: 169-178.
- National Institute of Occupational Safety and Health (NIOSH). 2003. NIOSH Alert: Preventing Phosphine Poisoning and Explosions During Fumigation. NIOSH, Columbus, Ohio, 1-6 and 99-126.
- Newton, P. 1997. 2-Year Combined Inhalation Chronic Toxicity and Oncogenicity Study of Phosphine in Rats (52-Week Interim Sacrifice Report): Lab Project Number: 750-001: 750-001 (INTERIM). Unpublished study prepared by MPI Research. 615 p. (As cited in USEPA, 1998).
- Noble, R. M. and D. J. Hamilton. 1985. Stability of Cypermethrin and Cyfluthrin on Wheat in Storage. *Pesticide Science* 16: 179-185.
- Nukenine, E. N. 2010. Stored Product Protection in Africa: Past, Present and Future. In *Proceedings of the 10th International Working Conference on Stored Product Protection*, June 27 – July 2, 2010, Estoril, Portugal. *Julius-Kühn-Archiv*. 425: 26 – 41. Available at <http://pub.jki.bund.de/index.php/JKA/issue/view/719>.
- Obeng-Ofori, D. 2011. Protecting Grain From Insect Pest Infestations in Africa: Producer Perceptions and Practices. *Stewart Postharvest Review* 3: 1-15.
- Oberlander, H. and D. L. Silhacek. 2000. Insect Growth Regulators, pp. 147-163. In *Alternatives Pesticides for Stored-Product IPM*, Subramanyam, Bh., And D. W. Hagstrum (ed.), Kluwer Academic Publishers, Massachusetts.
- Occupational Safety and Health Administration (OSHA). 1989. 29 CFR Part 1910, Preamble to Final Rule, Air Contaminants, Section 6 - Health Effects Discussion and Determination of Final PEL. Retrieved April 16, 2012 from http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_id=770&p_table=PREAMBLES
- Pan, C., W. Li, and S. Jiang. 2005. Study on the XPS-ESCA of Aluminum Phosphide Products. *International Journal of Molecular Sciences* 6: 198-202.
- Paulozzi, L. J., and J. M. Lary 1999. Laterality Patterns in Infants with External Birth Defects. *Teratology* 60: 265–271. (As cited in Garry, et al., 2002).
- Parkin, E. A. 1966. The Relative Toxicity and Persistence of Insecticides Applied as Water-Dispersible Powders Against Stored-Product Beetles. *Annals of Applied Biology* 57: 1-4.

- Pepelko, J. Seckar, P. R. Harp, J. H. Kim, D. Gray, and E. L. Anderson. 2004. Worker Exposure Standard for Phosphine Gas. *Risk Analysis* 24: 1201-1213.
- Plarre, R., and F. Reichmuth. 2000. Impact, pp. 401-417. In *Alternatives to Pesticides for Stored-Product IPM*, Subramanyam, Bh., and D. W. Hagstrum (ed.). Kluwer Academic Publishers, Boston, Massachusetts.
- Plimmer, J. R. 1977. The Effect of Fumigants on Food Quality. *Journal of Food Safety* 1: 87-105.
- Pratt, S. J. 1998. Ambient Air Phosphine Readings in and Around Grain Stores Under Fumigation. Cooperative Bulk Handling Ltd., Western Australia, Technical Report No. 80, CSIRO, Canberra, Australia, 9 pages.
- Preisser, A.M., L.T. Budnik, E. Hampel, and X. Baur. 2011. Surprises Perilous: Toxic Health Hazards for Employees Unloading Fumigated Shipping Containers. *Science of the Total Environment* 409: 3106-3113.
- Rangaswamy, J. R., and N. Gunasekaran. 1996. Phosphine Residue and its Desorption From Legumes Fumigated With Phosfume Pellets. *Food Science and Technology* 29: 234-237.
- Raghunatan, A. N., and S. K. Majumder. 1969. Control of Internal Fungi of Sorghum by Fumigation. *Journal of Stored Products Research* 5: 389-392.
- Rainier, S., M. Bui, E. Mark, D. Thomas, D. Tokarz, L. Ming, C. Delaney, R. J. Richardson, J. W. Albers, N. Matsunam, J. Stevens, H. Coon, M. Leppert, and J. K. Fink. 2008. Neuropathy Target Esterase Gene Mutations Cause Motor Neuron Disease. *The American Journal of Human Genetics* 82: 780-785.
- Rajak, R. L. 1971. Studies Concerning the Toxic and Physiological Effects of Phosphine on Insects for Some Pest Species. PhD Thesis, University of London.
- Rajendran, S., and N. Muralidharan. 2001. Performance of Phosphine in Fumigation of Bagged Paddy Rice in Indoor and Outdoor Stacks. *Journal of Stored Products Research* 37: 351-358.
- Rauscher, H., G. E. Mayr, and J. B. Sullivan. 1972. Sorption and recovery of phosphine. *Journal of Agricultural Food and Chemistry* 20: 331-333.
- Reichmuth, C., B. Schneider, and M. J. Drinkall. 1999. Sulfuryl fluoride (Vikane®) Against Eggs of Different Age of the Indian Meal Moth *Plodia interpunctella* (Hübner) and the Mediterranean Flour Moth *Ephesia kuehniella* (Zeller), pp. 416-422. In *Proceedings of the Seventh International Working Conference on Stored Product Protection*, Zuxun, J., L. Quan, L. Yongsheng, T. Xianchang, and G. Lianghua, (ed.), 14-19 October 1998, Beijing, China. Sichuan Publishing House of Science and Technology, Beijing, China.
- Reed, C., and H. Pan. 2000. Loss of Phosphine from Unsealed Bins of Wheat at Six Combinations of Grain Temperature and Grain Moisture Content. *Journal of Stored Products Research*, 36: 263-279.
- Robinson, J. R., and E. J. Bond. 1970. The Toxic Action of Phosphine: Studies with 32PH₃; Terminal Residues in Biological Materials. *Journal of Stored Products Research* 6: 133-146.

- Roesli, R., Bh. Subramanyam, J. F. Campbell, and K. Kemp. 2003. Impact of Selected IPM Practices on Insect Populations in Retail Pet Stores, pp. 410-419. In *Advances in Stored Product Protection: Proceedings of the 8th International Working Conference on Stored Product Protection*, July 22-26, 2002, York, United Kingdom, Credland, P. F., D. M. Armitage, C. H. Bell, P. M. Cogan, and E. Highley (ed.). CAB International, Wallingford, Oxon, United Kingdom.
- Sanon, A., L. C. Dabiré-Binso, and N. M. Ba. 2011. Triple-Bagging of Cowpeas Within High Density Polyethylene bags to control the cowpea beetle, *Callosobruchus maculatus* F. (Coleoptera: Bruchidae). *Journal of Stored Products Research* 47: 210-215.
- Seck, D., G. Longnay, E. Haubruge, M. Marlier, and C. Gasper. 1996. Alternative Protection of Cowpea Seeds Against *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae) Using Hermetic Storage Alone or in Combination with *Boscia senegalensis* (Pers.) Lam. Ex Poir. *Journal of Stored Products Research* 32: 39-44.
- Sechzer, P.H. L. D. Egbert, H. W. Linde, D. Y. Cooper, R. D. Dripps, and H. L. Price. 1960. Effect of CO₂ Inhalation on Arterial Pressure, ECG and Plasma Catecholamines and 17-OH Corticosteroids in Normal Man. *Journal of Applied Physiology* 15: 454-458.
- Schneider, B. and P. Hartsell. 1999. Control of Stored Product Pests with Vikane® Gas Fumigant (Sulfuryl Fluoride), pp. 406-408. In *Proceedings of the Seventh International Working Conference on Stored Product Protection*, Zuxun, J., L. Quan, L. Yongsheng, T. Xianchang, and G. Lianghua, (ed.), 14-19 October 1998, Beijing, China. Sichuan Publishing House of Science and Technology, Beijing, China.
- Siemering, G. 2004. Aquatic Pesticide Monitoring Project Report Phase 2 (2003): Monitoring Project Report. SFEI contribution 108. San Francisco Estuary Institute, Oakland, CA. Available at <http://www.sfei.org/apmp/reports/APMPPPhase2Final.pdf>.
- Singh, K. N., and B. P. Srivastava. 1980. Studies on the Efficacy and Extent of Residues of Phosphine in Stored Pulses. *Pesticides* 14: 32.
- Sinha, R. N., D. Berek, and H. A. H. Wallace. 1967. Effect of Phosphine on Mites, Insects, and Microorganisms. *Journal of Economic Entomology* 60: 125-132.
- Subramanyam, Bh. 2007a. Impact Machines: A look back. *Milling Journal*, Third Quarter, pp. 38-39.
- Subramanyam, Bh. 2007b. Impact Machines: Experiments. *Milling Journal*, Fourth Quarter, pp. 36-38.
- Subramanyam, Bh., and L. K. Cutkomp. 1987. Influence of Posttreatment Temperature on Toxicity of Pyrethroids to Five Species of Stored-Product Insects. *Journal of Economic Entomology* 80: 9-13.
- Subramanyam, Bh., and D. W. Hagstrum. 1996. Resistance Measurement and Management, pp. 331-397. In *Integrated Management of Insects in Stored Products*, Subramanyam, Bh. and D. W. Hagstrum. (ed.). Marcel Dekker, Inc., New York.
- Subramanyam, Bh., and P. K. Harein. 1986. Effect of Bioallethrin and Cyfluthrin on Knockdown and Mortality of Indianmeal Moth and Almond Moth Larvae. *Journal of Agricultural Entomology* 3: 310 - 314.

- Subramanyam, Bh. and R. Roesli. 2000. Inert Dusts, pp. 321-380. In *Alternatives to Pesticides in Stored-Product IPM*, Subramanyam, Bh., and D. W. Hagstrum. (ed.). Kluwer Academic Publishers, Boston, Massachusetts.
- Subramanyam, Bh., R. Mahroof, and M. Brijwani. 2011. Heat Treatment of Food-Processing Facilities for Insect Management: A Historical Overview and Recent Advances. *Stewart Postharvest Review* 3: 1-11.
- Subramanyam, Bh., Roesli, R., J. Breusch, and A. Menon. 2005. Sanitation and Pest Management, Chapter 47, pp. 415-431. In, Schofield, E. K. (ed.), *Feed Manufacturing Technology V*, American Feed Industry Association, Arlington, Virginia.
- Swella, G. B., and D. M. K. Mushobozy. 2007. Evaluation of the Efficacy of Protectants Against Cowpea Bruchids (*Callosobruchus maculatus* (F.)) on Cow Pea Seeds (*Vigna unguiculata* (L.)). *Plant Protection Science* 43: 68-72.
- Takahashi, O., S. Oishi, T. Fujitani, T. Tanaka, and M. Yoneyama. 1994. Chronic Toxicity Studies of Piperonyl Butoxide in F344 Rats: Induction of Hepatocellular Carcinoma. *Fundamentals of Applied Toxicology* 22: 293-303.
- Throne, J. E., J. E. Baker, F. J. Messina, K. J. Kramer, and J. A. Howard. 2000. Varietal Resistance, pp. 164-192. In *Alternatives to Pesticides in Stored-Product IPM*, Subramanyam, Bh., and D. W. Hagstrum (ed.). Kluwer Academic Publishers, Boston, Massachusetts.
- Tilley, D.R., M.E. Casada, and F.H. Arthur. 2007. Heat Treatment for Disinfestation of Empty Grain Storage Bins. *Journal of Stored Products Research* 43: 221-228.
- Tilton, E. W., and J. H. Brower. 1973. Status of the U.S. Department of Agriculture Research and Irradiation Disinfestation of Grain and Grain Products, pp. 295-309. In *Radiation Preservation of Food*, IAEA-SM-166/49, IAEA, Vienna.
- Tilton, E. W., W. E. Burkholder, and R. R. Cogburn. 1966. Effects of Gamma Radiation on *Rhyzopertha dominica*, *Sitophilus oryzae*, *Tribolium castaneum*, and *Lasioderma serricornis*. *Journal of Economic Entomology* 59: 1363-1368.
- Tkachuk, R. 1972. Phosphorus Residues in Wheat Due to Phosphine Fumigation. *Cereal Chemistry*, 49: 258-267.
- Toews, M. D., J. F. Campbell, and F. H. Arthur. 2006. Temporal Dynamics and Response to Fogging or Fumigation of Stored-Product Coleoptera in a Grain Processing Facility. *Journal of Stored Products Research* 42: 480-498.
- Toews, M. D., J. F. Campbell, and F. H. Arthur. 2010. The Presence of Flour Affects the Efficacy of Aerosolized Insecticides Used to Treat the Red Flour Beetle, *Tribolium castaneum*. *Journal of Insect Science* 10: 196 available online: insectscience.org/10.196.
- Tucker, J. D., D. H. Moore, M. J. Ramsey, P. Kato, R. G. Langlois, B. Burroughs, L. Long, V. F. Garry. 2003. Multi-endpoint Biological Monitoring of Phosphine Workers. *Mutation Research* 536: 7-14.

United Nations Educational, Scientific and Cultural Organization (UNESCO). 2007. Integrating Women in Development Planning- The Role of Traditional Wisdom. M. A. Singamma Sreenivasan Foundation, Bangalore, India. Available at <http://unesdoc.unesco.org/images/0008/000846/084699eo.pdf>.

USAID. 2006. United States Agency for International Development Commodities Reference Guide. Available at http://www.usaid.gov/our_work/humanitarian_assistance/ffp/crg.

USAID-BEST. 2009. United States Agency for International Development-Bellmon Estimation for Title II project. USAID office of Food for Peace Bangladesh Bellmon Estimation. Fintrac Inc.

USAID. 2011. Scoping Statement for the Programmatic Environmental Assessment for Title II Food Aid Commodity Protection and Fumigation. June.

United States Environmental Protection Agency (USEPA). 2000. Technology Transfer Network Air Toxics Web Site, Phosphine. Hazard Summary, Updated January 2000; website last updated November 6, 2007. Retrieved April 19, 2012, from <http://www.epa.gov/ttn/atw/hlthef/phosphin.html>

USAID FFP. 2010. United States Agency for International Development Food for Peace Fact Sheets. Retrieved May 17, 2012, from <http://foodaid.org/food-aid-programs/food-for-peace/>.

USAID FFP. 2011. United States Agency for International Development Food for Peace Fact Sheets. Retrieved May 17, 2012, from <http://foodaid.org/food-aid-programs/food-for-peace/>.

U.S. International Food Assistance Report. 2010. United States Department of Agriculture and United States Agency for International Development. USAID Development Experience Clearinghouse . Available online at: <http://www.dec.org/>, <http://www.usaid.gov> and at <http://www.fas.usda.gov>

United States Environmental Protection Agency (USEPA). 1982. Guidance for the Reregistration of Pesticide Products Containing Methoprene as the Active Ingredient. Office of Pesticide Programs, Washington, D. C.

United States Environmental Protection Agency (USEPA). 1991. Reregistration Eligibility Document Database for Methoprene (40596-69-8). Office of Pesticide Programs, Washington D. C. Available: http://www.epa.gov/REDs/old_reds/methoprene.pdf

USEPA. 1992. Reference Guide to Odor Thresholds for Hazardous Air Pollutants Listed in the Clean Air Act Amendments of 1990. EPA/600/R92/047, Office of Research and Development, March 1992. Available on the Internet at: <http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=40610#Download>

United States Environmental Protection Agency (USEPA). 1998. Reregistration Eligibility Decision (RED), Al and Mg Phosphide. EPA 738-R-98-017, Prevention, Pesticides, and Toxic Substances, December 1998. Available at <http://www.epa.gov/oppsrrd1/REDs/0025red.pdf>.

USEPA. 2000. Technology Transfer Network Air Toxics Web Site, Phosphine. Hazard Summary, Updated January 2000; website last updated November 6, 2007. Retrieved April 19, 2012, from <http://www.epa.gov/ttn/atw/hlthef/phosphin.html>

United States Environmental Protection Agency (USEPA). 2001. June 2001 update of the March 1991 Methoprene R.E.D. Factsheet. Available at http://www.epa.gov/oppbppd1/biopesticides/ingredients/factsheets/factsheet_105401.pdf.

United States Environmental Protection Agency (USEPA). 2003. Integrated Risk Information System (IRIS) Profile for Phosphine. Last updated October 28, 2003. Available on the Internet at: <http://www.epa.gov/iris/subst/0090.htm>

United States Environmental Protection Agency (USEPA). 2007. Revised N-Methyl Carbamate Cumulative Risk Assessment. US Environmental Protection Agency, Office of the Pesticide Programs, Washington, D. C.

United States Environmental Protection Agency (USEPA). 2011. Pyrethrins/Pyrethroid Cumulative Risk Assessment. US Environmental Protection Agency, Office of the Pesticide Programs, Washington, D. C.

van Someren Graver, J. E. 2004. Guide to Fumigation Under Gas Proof Sheets. Australian Government, Australian Center for International Agricultural Research, Food and Agriculture Organization of the United Nations, Rome, Italy.

Watters, F. L., and K. F. MacQueen. 1967. Effectiveness of Gamma Radiation for Control of 5 Species of Stored Product Insects. *Journal of Stored Products Research* 3: 223-234.

Wilson, R., F. H. Lovejoy, R. J. Jaeger, and P. L. Landrigan. 1980. Acute Phosphine Poisoning Aboard a Grain Freighter: Epidemiologic, Clinical, and Pathological Findings. *Journal of American Medical Association* 244: 148-150.

Wijayaratne, L. K. W., P. G. Fields, and F. H. Arthur. 2011. Effect of Methoprene on the Progeny Production of *Tribolium castaneum* (Coleoptera: Tenebrionidae). *Pest Management Science* 68: 217-224.

White, N. D. G., and J. G. Leesch. 1996. Chemical Control, pp. 287-330. In *Integrated Management of Insects in Stored Products*, Subramanyam, Bh., and D. W. Hagstrum (ed.), Marcel Dekker, Inc., New York.

Wong, K. L. 1992. Carbon Dioxide. Internal Report, Johnson Space Center Toxicology Group. National Aeronautics and Space Administration, Houston, Texas.

Wontner-Smith, T. J. 2005. Evaluation of the Use of Sulfuryl Fluoride (Profume™) in the Malting Industry in the United Kingdom. HGCA Research Review No. 55. Home- Grown Cereals Authority, London, United Kingdom.

Wright, J. E. 1976. Environmental and Toxicological Aspects of Insect Growth Regulators. *Environmental Health Perspectives* 14: 127-132.

WEBLINKS

http://www.usaid.gov/our_work/humanitarian_assistance/ffp/crg/sec4.htm: USAID Commodity Reference Guide-Section IV. Controlling Damage to Food Commodities.**

<http://www.usaidgems.org/fumigationpea.htm>

<http://www.aces.edu/pubs/docs/A/ANR-1154/>: Fumigating Agricultural Commodities With Phosphine. Alabama Cooperative Extension System. ANR-1154.

<http://www.cyttec.com>: Cytec Industries, Inc.

<http://graintechsystems.com/Fumigation.htm>: Phosphine Fumigation System for Insect Control in Stored Grain. Grain Tech Systems (GTS) in Association with HuaiRen Technology Company, Ltd.

http://www.usaid.gov/our_work/humanitarian_assistance/ffp/crg/sec2.htm: USAID Commodity Reference Guide-Section II. Commodity Fact Sheets.**

http://pdf.usaid.gov/pdf_docs/PNACK393.pdf: USAID Commodities Reference Guide, Version 1999/2000.

http://www.usaid.gov/our_work/humanitarian_assistance/ffp/bellmonana.html: USAID FFP Bellmon Studies.

http://www.usaid.gov/our_work/humanitarian_assistance/ffp/reg11p.htm: USAID FFP: FY 2007 Final Guidelines and Procedures-v2.

<http://www.worldportsource.com/countries.php>: World Port Source.

<http://www.worldvision.org>: World Vision-Building a Better World for Children.

http://www.epa.gov/oppsrrd1/reregistration/alphosphide/fumigation_qa.pdf: US-EPA Phosphine Fumigant Labeling, Questions and Answers.

<http://www.eco2.nl>: EcO₂-Fumigation in a Natural Way.

<http://www.ag.purdue.edu/ipia/pics>: Purdue Agriculture-Purdue Improved Cowpea Storage

<http://www.grainpro.com>: GrainPro, Inc., Storing the Future.

<http://www.provisiongard.com/empirical.html>: ProvisionGard Technology, LLC: Safe, targeted Insect Protection.

http://www.agmcontainer.com/desiccantcity/desiccant_oxygen_absorbers.htm?gclid=CL-pnrGrpLACFSdeTAodExLLXA: AGM Oxygen Absorbers.

<http://www.fda.gov/food/guidancecomplianceregulatoryinformation/guidancedocuments/sanitatio n/ucm056174.htm>: US Food and Drug Administration, Protecting and Promoting Your Health.

Defect Levels Handbook. The Food Defect Action Levels. Levels of Natural or Unavoidable Defects in Food That Present No Health Hazards for Humans.

<http://temp-air.com/contactus.aspx>: Temp-Air, Inc., Burnsville, Minnesota.

<http://www.coolseed.com.br>: Coolseed, Iguassu Falls, Brazil.

<http://www.frigortec.de>: Frigot Tec GmbH-Cooling to the Point, Amtzell, Germany.

<http://www.fs.fed.us/r6/invasiveplant-eis/Region-6-Inv-Plant-Toolbox/Herbicide%20Info/EPA-Toxicity-Categories-081607ver.pdf>: EPA Toxicity Categories.

<http://foodaid.org/food-aid-programs/food-for-peace/>: USAID Food Aid and Security-Food for Peace.

<http://www.pic.int/Countries/CountryProfile/tabid/1087/language/en-US/Default.aspx>: Rotterdam Convention. Country Profile. United Nations Environmental Program (UNEP), Secretariat of the Stockholm Convention, Châtelaine, Switzerland and Secretariat of the Rotterdam Convention-FAO, Rome, Italy.

<http://www.pops.int>: Stockholm Convention-Protecting Human Health and the Environment from Persistent Organic Pollutants. United Nations Environmental Program (UNEP), Secretariat of the Stockholm Convention, Châtelaine, Switzerland.

<http://www.basel.int/>: Basel Convention-Controlling Transboundary Movements of Hazardous Wastes and Their Disposal. United Nations Environmental Program (UNEP), Secretariat of the Stockholm Convention, Châtelaine, Switzerland.

<http://www.unep.org/OZONE/pdfs/Montreal-Protocol2000.pdf>: United Nations Environmental Program. Environment for Development (document no longer available at this link). Document is available at the following link: <http://ozone.unep.org/pdfs/Montreal-Protocol2000.pdf>

<http://www.foodquality.wfp.org>: World Food Programme-Food Quality Control. The United Nations World Food Programme. Information on Fumigation can be Accessed from the Following Link:
(<http://foodquality.wfp.org/FoodSafetyandHygiene/PestManagement/Fumigation/tabid/322/Default.aspx?PageContentMode=1>)

http://www.draeger.us/sites/enus_US/pages/Mining/tubes-for-short-term-measurements.aspx: Dräger-Dräger Tubes for Short-term Measurements. Drägerwerk AG & Co., Draeger Safety Inc., Pittsburgh, Pennsylvania.

<http://www.pestproducts.com/bird-diseases.htm>: Bird Diseases.

<http://pmep.cce.cornell.edu/profiles/insect-mite/mevinphos-propargite/pirimiphos-methyl/insect-prof-actellic.html>: Pirimiphos-Methyl (Actellic) Chemical Fact Sheet 6/85, Cornell University, Ithaca, New York.

<http://www.cdpr.ca.gov/docs/emon/pubs/fatememo/carbaryl.pdf>: Environmental Fate of Carbaryl. Environmental Monitoring & Pest Management, Department of Pesticide Regulation, Sacramento, California.

http://www.epa.gov/oppbopd1/biopesticides/ingredients/factsheets/factsheet_igr.htm: US-EPA-Insect Growth Regulators: S-Hydroprene (128966), S-Kinoprene (107502), Methoprene (105401), S-Methoprene (105402) Fact Sheet.

http://pmep.cce.cornell.edu/profiles/insect-mite/mevinphos-propargite/pyriproxyfen/pyriprox_tol_0802.html: Pyriproxyfen-Pesticide Residue Tolerances 8/02, Cornell University, Ithaca, New York.

<http://www.cdms.net/ldat/mp48S001.pdf>: Material Safety Data Sheet-ESTEEM® Ant Bait. Valent USA Corporation, Walnut Creek, California.

http://www.hc-sc.gc.ca/cps-spc/alt_formats/pacrb-dgapcr/pdf/pubs/pest/decisions/rd-dh/rd2007-03-eng.pdf: Registration Decision-Pyriproxyfen RD2007-03. Pest Management Regulatory Agency, Health Canada, Ottawa, Ontario, Canada

<http://www.osha.gov/dsg/topics/silicacrystalline/index.html>: Silica, Crystalline. United States Department of Labor, Occupational Safety & Health Administration, Washington, D. C.

<http://gemini.info.usaid.gov/egat/envcomp/>: USAID Environmental Compliance Database.

**The weblink is unavailable as of June 21, 2012, because the site is under construction.

ANNEX T-I

GUIDE: TITLE II PARTNER PHOSPHINE FUMIGATION COMPLIANCE

With the approval of the “Commodity Protection in Title II 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 Title II 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 Title II program implementation and management, including the basics of environmental compliance for Title II activities.

OVERVIEW OF FOOD ASSISTANCE PROGRAM FUMIGATION COMPLIANCE

Title II 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 Title II 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

Title II 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-5
 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 Title II 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 Title II 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 Title II 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 Title II 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.

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ANNEX T-2

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

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

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, 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.

ANNEX T-3

TEMPLATE: FUMIGATION MANAGEMENT PLAN (FMP) FOR PHOSPHINE FUMIGATION OF TITLE II 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 Title II Partners. As described in Annex T-1, fumigation compliance requires Title II 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. Title II 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 Title II 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 Title II Food Commodities in sheeted stacks in a form that: (1) guides a trained fumigator to produce safe and efficacious results, (2) allows a Title II 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://aciagov.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/pesticid/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>.

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 CONTRACT

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.]

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 TITLE II 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:

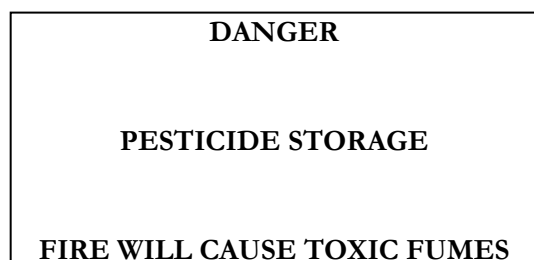
- Storage of pesticide containers (including fumigants)
- Disposal of pesticide containers (including fumigants)
- Transport of pesticides (including fumigants)
- Determining when to fumigate
- Soliciting and contracting for fumigation services
- Fumigation of stacks with aluminum phosphide
- Specifications 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 Title II 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 Title II 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

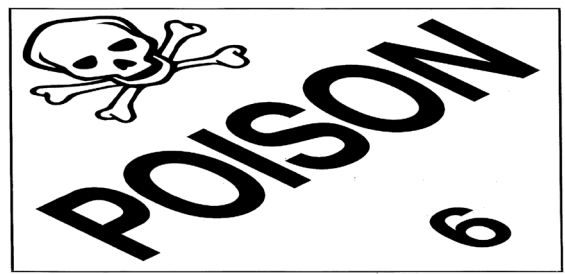
1. No more than 21 kg of aluminum phosphide may be transported by motor vehicles at any one time.
2. The complete packages must be stowed in metal boxes or compartments on the motor vehicle.
3. Only licensed pest control operators may transport the packages.
4. Each canister or foil pouch and the outer 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 1 meter 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 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, Title II 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 thorough 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>

Inserting DegeschPhostoxinAluminumPhosphideMsd

<http://dec.alaska.gov/spar/perp/MarineDebris/Aluminum%20Phosphide%20MSDS.pdf>

and US PA phosphine factsheet

http://www.epa.gov/opp00001/chem_search/reg_actions/registration/fs_PC-066500_01-Dec-99.pdf

as PDFs into final document

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



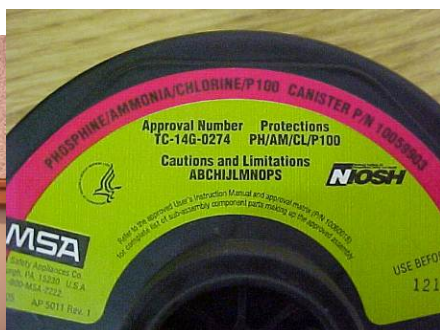
Air-purifying, half mask respirator
with canister



Supplied air respirator with full face mask



Fit Test for Cartridges to Determine
Tight Fit



Read Information on
Cartridges/Canisters

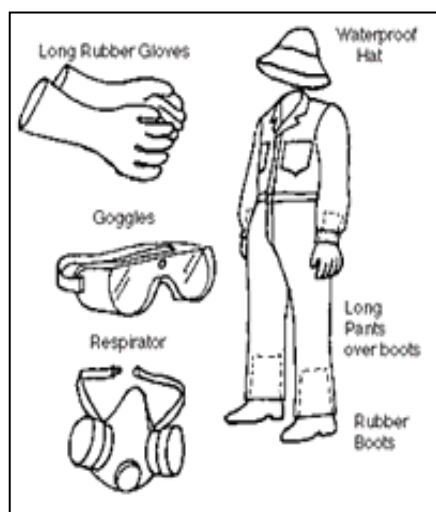


Self-Contained Breathing Apparatus



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.



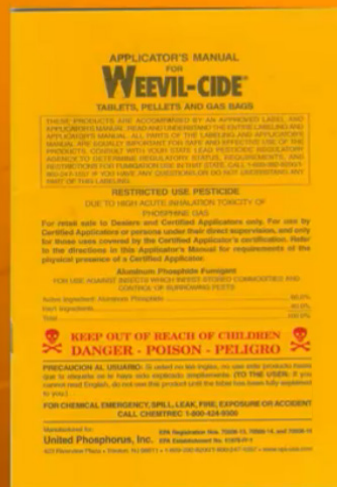
IF IN EYES



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.

Have a copy of the Applicator's Manual with you.

- ◆ If you have to take someone for medical attention. Make sure you take a current copy of the brand of aluminum phosphide you are using with you for the doctor or medical attendant.



Sources:

- Photo and Illustrations courtesy of Kansas State University, Department of Grain Science and Technology from Lecture 9, Part 1 on *Fumigation Safety Considerations* by Brayn Giroux, 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-I I

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
Lepidoptera	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
	Pyrilidae	<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)



Plodia



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.

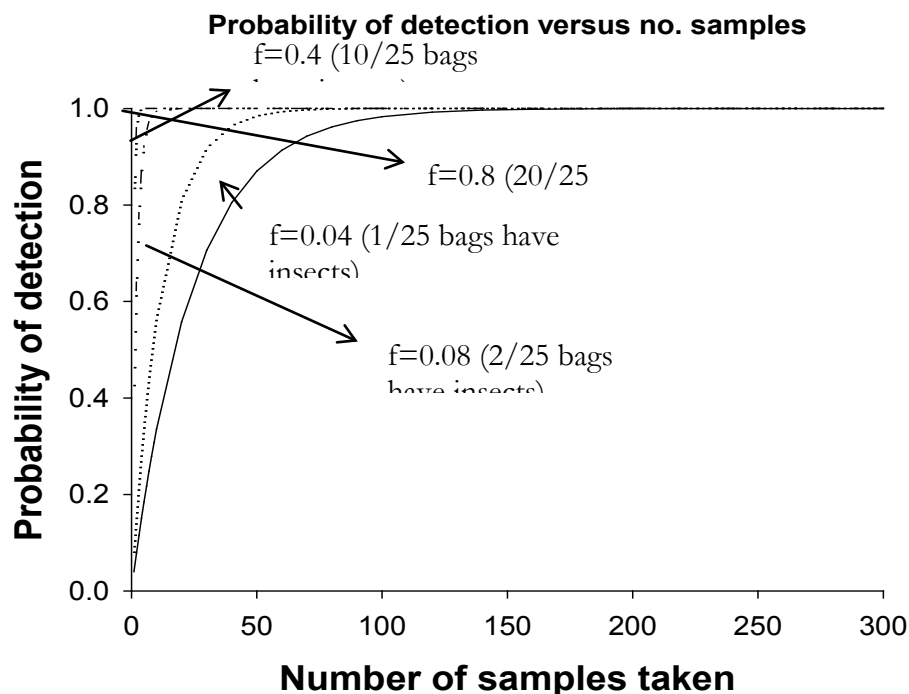


Figure 1. Relationship between Probability of Detection, Number of Samples, and Frequency of Infestation. The Inset Graph Shows the Same Four Lines Over 0 to 50 Samples.

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 (fmax) 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://ip1.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://aciagov.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.cardinalproproducts.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.controlequipment.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-entrepot/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.

NON-TOOLS ANNEX FOR THE COMMODITY PROTECTION BY PHOSPHINE FUMIGATION IN USAID FOOD AID PROGRAMS

PROGRAMMATIC ENVIRONMENTAL ASSESSMENT

PUBLIC REVIEW DRAFT

JULY 2013

ANNEX A. IN-TRANSIT FUMIGATION OF VESSELS WITH ALUMINUM/MAGNESIUM PHOSPHIDE FORMULATIONS

As a precautionary measure to disinfest commodities prior to shipment overseas, food aid is usually fumigated prior to arriving at a US port or once it arrives at the US port. Fumigants may include methyl bromide or sulfuryl fluoride; it is illegal to use them, however, for in-transit fumigation of vessels. In-transit fumigation of vessels is allowed only with aluminum/magnesium phosphide formulations. This treatment may not always guarantee an insect-free commodity when food aid arrives at a port in the receiving country. Since 1975, FGIS, in cooperation with the USDA's ARS and the grain, fumigant, and maritime industries, has been involved in research studies to develop safe, effective, and economical fumigation methods for bulk grain loaded aboard oceangoing vessels. Based on the data obtained from these studies, ARS has provided FGIS with recommendations for the safe and effective in-transit fumigation of bulk grain aboard several types of vessels. Accordingly, for bulk grain aboard certain carriers, FGIS has issued policies and procedures for in-transit fumigation with aluminum phosphide formulations.

- Fumigation of bulk grains in land carriers is authorized by section 800.84 (b) (3) of the regulations under the United States Grain Standards Act, as amended.
- The fumigation of bulk rice in land carriers is approved under the provisions of the 1946 Agricultural Marketing Act. Land carriers used for transporting bulk grains and rice (paddy, brown, or milled rice) include boxcars, hopper cars with covered tops that can be closed and secured, containers, and trucks with permanently enclosed tops. Grains in these carriers can be fumigated only if the carriers are stationary during the fumigation and aeration period. Boxcars are not approved for in-transit fumigation. Hatch and trough type hopper cars, and trucks, trailers, and containers with enclosed tops, sides, and bottoms are approved for in-transit fumigation if they are transported by rail within the US.
- Section 800.86(d)(1) of the regulations under the United States Grain Standards Act, and applicable provisions of the Agricultural Marketing Act of 1946, as amended, govern in-transit fumigation of bulk grain (barley, canola, corn, flaxseed, mixed grain, oats, rye, sorghum, soybeans, sunflower seed, triticale, and wheat) and rice in vessels.
- These Acts stipulate that for in-transit fumigation, only US EPA registered aluminum phosphide formulations may be used and must be applied by certified applicators or under the supervision of certified applicators. A certified applicator is any individual who is certified to use or supervise the use of RUPs covered by the certification (40 CFR 171.2 (h)).
- The certified applicator must inspect the vessel and verify that it is suitable for fumigation, and that no gas will leak into areas occupied by ship personnel.
- The applicators provide a written statement on company letterhead to FGIS or the agency requesting the fumigation regarding which tanks or holds are suitable for fumigation; reason for unsuitability must be clearly articulated. Both the certified applicator and the vessel's officer-in-charge sign the statement. The applicator will have a prefumigation conference with the vessel's officer-in-charge in the presence of FGIS or agency personnel and provide each party with an EPA-approved aluminum phosphide label.
- Additional signed written statement by the applicator on company's letterhead must include the identification of the tanks or holds to be fumigated; cubic capacity and depth of each hold or tank; date of fumigation; expected time to reach destination; the method of fumigant application; safety

precautions to be followed by the vessel's crew during the voyage; symptoms of exposure to the fumigant, and first-hand aid procedures in case of accidental exposure; determine if appropriate respiratory protection equipment and gas detection equipment are on board the vessel and at least two crew members knowledgeable in their use; a listing of vessel areas judged safe and unsafe areas during the fumigation; a listing of areas to be monitored daily for gas leakage; instructions for aerating the holds or tanks (tanks or holds should not be aerated at sea); and instructions for the retrieval and disposal of fumigant formulation residue and its accompanying packaging such as sachets, bag blankets, or sleeves upon arrival at the destination port.

- In accordance with EPA-registered label requirements for aluminum phosphide formulations and US Coast Guard regulations for shipboard fumigation (46 CFR 147A) and any applicable state and local laws, packaged aluminum phosphide formulations or systems to retain residual fumigant dust should be used after loading of the tank or hold is completed.
- The fumigated tanks or holds must remain closed and sealed for the entire voyage and should not be opened unless there is an emergency such as structural damage or fire.
- Warning placards must be placed on all entrances to the fumigated tanks or holds and on the outside of each manway. Each placard must show the skull and crossbones symbol and include the fumigation date, fumigant formulation used, and that the fumigated holds and tanks should not be aerated until arrival at the destination port. Placards must be in English or in the principal language of the vessel's crew.
- Typical time for vessel fumigation varies with the fumigant application method and commodity depth and may range from 3-18 days. FGIS officials must verify accuracy of information provided by the certified applicator, and attach a copy of all fumigation related documents to the Inspection Log (form FGIS-921) to have on file.
- Commodities such as bagged rice or grain, bagged commodities, or soybean meal that do not qualify for in-transit fumigation, but are fumigated in land carriers (as mentioned above) require an FGIS observer to witness the fumigation but not its efficacy against insects.
- If bulk grain or rough or brown rice for processing is infested, fumigation in accordance with procedures in the USDA's Fumigation Handbook must be followed. Once fumigated, an FGIS certificate will be issued as if the "infested" designation had never been issued. However, the US Sample Grade designation for milled rice with live or dead insects will remain in place.
- When fumigation is a quarantine requirement, it should be undertaken in accordance with the Fumigation Handbook procedures and the USDA's Animal and Plant Health Inspection Service (APHIS) will issue a phytosanitary certificate denoting that the commodity was fumigated. More information about the APHIS-FGIS Cooperative Agreement can be found in FGIS Directive 9180.35.

ANNEX B. AN ILLUSTRATION OF TITLE II FOOD AID COMMODITY SUPPLY CHAIN FROM EXPORT TO IMPORT COUNTRY

EXPORT COUNTRY (USA)					
STAGES IN THE SUPPLY CHAIN OF FOOD AID	1. PROCUREMENT OF FOOD AID	2. HANDLING	3. STORAGE OF FOOD AID AWAITING SHIPMENT	4. HANDLING	5. SHIPPING
LIKELY ACTIVITIES AT EACH STAGE	<ul style="list-style-type: none"> ▪ Determination of availability and amounts of surplus food commodity ▪ Design and development of emergency food aid programs and multi-year assistance programs specific for target countries needs ▪ Procurement of food aid 	<ul style="list-style-type: none"> ▪ Transfer of procured food aid commodity from a transportation carrier to a storage area ▪ Removal of cargo from carriers arriving at the warehouse or silo ▪ Tallying of received food commodity ▪ Segregation of any damaged or suspect units for further treatment ▪ Stacking of all sound units ▪ Inspection of all suspect units ▪ Salvage and reconstitution of 	<ul style="list-style-type: none"> ▪ Before stocking food aid commodity in storage facilities, the following have to be ensured: <ul style="list-style-type: none"> - Storage area is cleaned and dry - Application of contact pesticides ▪ Stored food commodity in grain silos, ware houses or other storage facility have to undergo the following: <ul style="list-style-type: none"> - Proper staking as required - Fumigated (pre-shipment fumigation) - Stock rotation - Frequent 	<ul style="list-style-type: none"> ▪ Transfer (receiving from, stacking, and loading into a transport carrier) of sound units of stored food aid commodity to a transportation carrier, in this case, a ship. ▪ Tallying of goods received from the storage facility and that loaded onto a ship for onward delivery, including noting of any unsound/damaged units 	<ul style="list-style-type: none"> ▪ Transportation of food aid commodity from export country port to import country port

		<p>any damaged units</p> <ul style="list-style-type: none"> Disposal of any commodities certified as unfit for human consumption 	<p>inspection of stock</p>		
<p>LIKELY STAKEHOLDERS AND INTERESTED PARTIES AT EACH STAGE</p>	<ul style="list-style-type: none"> United States (US) department of Agriculture USAID/DCHR/FFP USAID country Missions USAID Cooperating Sponsors with interest in the “import” country e.g. WFP 	<ul style="list-style-type: none"> Transportation company Survey company/firm or commodity brokers (acting on behalf of USAID/ DCHR/FFP, Cooperating Sponsors e.g. WFP) Silo and ware house managers Handling company managers and workers 	<ul style="list-style-type: none"> Survey company/firm or commodity brokers (acting on behalf of USAID/ DCHR/FFP, Cooperating Sponsors) Silo and ware house managers Silo and ware house workers Fumigation companies (fumigation workers) Fumigation training and certification companies USA Federal Grain Inspection Service (FGIS) official Public housing (nearby residents) in close proximity to fumigation sites of food 	<ul style="list-style-type: none"> Survey company/firm or commodity brokers (acting on behalf of USAID/ DCHR/FFP, Cooperating Sponsors e.g. WFP) Silo and ware house managers Handling company managers and workers Long- haul shipping company or vessel representative 	<ul style="list-style-type: none"> Long haul shipping company or vessel representative Survey company/firm or commodity brokers (acting on behalf of USAID/ DCHR/FFP, Cooperating Sponsors e.g. WFP)

IMPORT/RECIPIENT COUNTRY					
STAGES IN THE SUPPLY CHAIN OF FOOD AID	6. RECEIPT OF FOOD AID AT IMPORT COUNTRY PORT	7. HANDLING	8. PRIMARY STORAGE FACILITY	9. HANDLING	10. SECONDARY STORAGE FACILITY OR TRANSFER TO A DISTRIBUTION CENTRE
LIKELY ACTIVITIES AT EACH STAGE	<ul style="list-style-type: none"> ▪ Inspection and clearance of food aid commodity by recipient country's customs official(s), or ▪ Transfer of the food aid commodity to a bonded ware house awaiting inspection and clearance by import country custom's official (s), government agency or health department representative 	<ul style="list-style-type: none"> ▪ Transfer of food aid commodity from a transportation carrier (ship vessel) to a primary storage area ▪ Tallying of goods received ▪ Segregation of any damaged or suspect units for further treatment ▪ Stacking of all sound units ▪ Inspection of all suspect units ▪ Salvage and reconstitution of any damaged units ▪ Disposal of any commodities 	<ul style="list-style-type: none"> ▪ Before stocking food aid in storage facilities, the following have to be ensured: <ul style="list-style-type: none"> - Storage area is cleaned and dry - Application of contact pesticides ▪ Stored food commodity in grain silos, ware houses or other storage facility have to be: <ul style="list-style-type: none"> - Accounted/docum ented - Staked as stipulated - Fumigated - Stock rotation - Frequent inspection of stock 	<ul style="list-style-type: none"> ▪ Transfer (receiving from, stacking, and loading out on to transport) of stored food commodity to a transportation carrier. ▪ Tallying of goods received from the storage facility and that loaded onto a transportation carrier for onward delivery, including noting of any unsound/damaged units 	<ul style="list-style-type: none"> ▪ If, a secondary storage facility further inland or at a regional hub at the recipient country, the activities ad stakeholders for this stage are likely similar to that of stage 8. ▪ If, a distribution centre, activities are likely to be: <ul style="list-style-type: none"> - Tallying of goods received - Segregation of any damaged or suspect units for further treatment - Stacking of all sound units - Inspection of all

		certified as unfit for human			suspect units <ul style="list-style-type: none"> - Salvage and reconstitution of any damaged units - Disposal of any commodities certified as unfit for human consumption - Distribution of quality food aid to recipients
LIKELY STAKEHOLDERS AND INTERESTED PARTIES AT EACH STAGE	<ul style="list-style-type: none"> ▪ Survey company/firm or commodity brokers (acting on behalf of USAID/ DCHR/FFP, Cooperating Sponsors) ▪ Recipient country customs, government agency or health department representative 	<ul style="list-style-type: none"> ▪ Survey company/firm or commodity brokers (acting on behalf of USAID/ DCHR/FFP, Cooperating Sponsors) ▪ Silo and ware house managers ▪ Transportation company ▪ Handling company managers and workers ▪ Recipient country 	<ul style="list-style-type: none"> ▪ Survey company/firm or commodity brokers (acting on behalf of USAID/ DCHR/FFP, Cooperating Sponsors) ▪ Silo and ware house managers ▪ Silo and ware house workers ▪ Fumigation companies (fumigation workers) ▪ Recipient country's grain inspection service official ▪ Public housing in close proximity to fumigation 	<ul style="list-style-type: none"> ▪ Survey company/firm or commodity brokers (acting on behalf of USAID/ DCHR/FFP, Cooperating Sponsors) ▪ Silo and ware house managers ▪ Handling company managers and workers ▪ Transportation company 	<ul style="list-style-type: none"> ▪ USAID/ DCHR/FFP, Cooperating Sponsors staff ▪ Distribution site temporary storage facility manager(s) and workers ▪ Recipient community

		customs <ul style="list-style-type: none"> ▪ Recipient country's grain inspection service official (s) 	sites of food commodity		
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Constructed with reference to:

Food for the Hungry, Inc. 2010. Commodity Management Manual- Level 300 Freight. Phoenix, Arizona.

Hale, H., and Franciscovich, W., (ed). 1999. Commodity management enhancement project- Food Aid Logistics Operational Handbook. CARE, USA

USAID. 2011. Scoping statement for programmatic environmental assessment (PEA) for Title II Food Aid Commodity Protection and Fumigation, Environmentally Sound Design and Management Capacity-building in Africa (ENCAP).

ANNEX C. SCOPING STATEMENT (EXCERPTS)

The environmental regulations (22 Code of Federal Regulations, Part 216) of the United States Agency for International Development (USAID) commonly referred to as Reg. 216, establish the conditions and procedures for the environmental review of activities funded with Agency resources.

This Scoping Statement is being developed to guide a Programmatic Environmental Assessment (PEA) of the current activities associated with the protection and management of food aid commodities from procurement to distribution and with particular attention to fumigation practices.

As part of the effort to both prepare this Scoping Statement and lay the groundwork for the eventual PEA, the FFP Office mandate to the contractor called for the establishment and operationalization of a Sharepoint site (<http://encap.sharepoint.afr-usd.org/envofficers/fumigationpea/default.aspx?>).

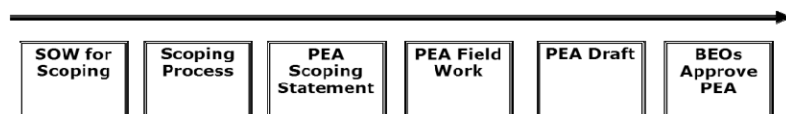


Figure 1 – Logic pathway for scoping and completion of PEA including stakeholder consultation and fieldwork as primary data gathering methodologies.

The USAID Food For Peace (FFP) office, through funding provided by the 2008 Farm Bill, 207(f) Oversight Authority under the Food for Peace Act, Public Law 480, Title II, makes agricultural commodity donations to Cooperating Sponsors [CSs: Private Voluntary Organizations (PVOs) or Non-Governmental Organizations (NGOs), Cooperatives, and Public International Organization Agencies, e.g., the UN's World Food Program (WFP)] to address food security in both development and emergency food assistance programs. This distinction between emergency and non-emergency food aid is of interest here because traditionally emergency food aid is procured, transported and distributed more quickly than development program food aid, thus minimizing its exposure to pests and the need for protection/fumigation. In many instances, some emergency food aid commodities are "pre-positioned" at USAID run warehouses strategically located around the world. These commodities, as a matter of policy, are only stored for two months before being rotated out and restocked (personal communication, 2011, G. Olson/USAID/FFP).

Programs that Title II supports include but are not limited to direct commodity distribution, Food for Work (e.g., road rehabilitation), and commodity monetization to support an array of development activities (e.g., maternal-child health, agriculture, water/sanitation). Most of these commodities (with the exception of tinned food aid commodities such as vegetable oil) are fumigated with pesticides as they are made ready for shipment from the US or during transit. Primary warehouses where Title II commodity is discharged off shipping vessels and title transferred are found in all four regions where USAID operates. Table - List of Title II Development and Emergency Discharge Ports Worldwide

COUNTRY	DISCHARGE PORT	COUNTRY	DISCHARGE PORT
Africa Region			
Burkina Faso	Lome, Tema	Burundi	Dar es Salaam
CAR	Doula	Chad	Benghasi, Doula
Cote D'Ivoire	Abidjan	Ethiopia	Djibouti
Ghana	Tema	Guinea	Conakry
Kenya	Mombasa	Lesotho	Durban (SA)

Liberia	Monrovia	Madagascar	Toliara, Toamasina
Mali	Lome	Mauritania	Nouakchott
Malawi	Beira (Moz), Nacala (Moz), Durban (SA)	Mozambique	Beira, Maputo
Niger	Cotonou	Rwanda	Mombasa, Kigali
Sudan	Mombasa, Djibouti, Port Sudan	South Africa	Durban
Somalia	Mombasa	Senegal	Dakar
Swaziland	Durban (SA), Maputo (Moz)	Zambia	Durban (SA), Beira (Moz)
Zimbabwe	Durban (SA), Beira (Moz)		
Europe & Eurasia Region			
Afghanistan	Qasim	Tajikistan	Dushambe
Asia-Near East Region			
East Timor	Dili	Nepal	Calcutta
Bangladesh	Chittagong	India	Mumbai, Calcutta
Indonesia	Atapupu		
Latin America & the Caribbean Region			
Colombia	Barranquilla	Haiti	Gonaives, Callao, Port au Prince
Honduras	Puerto Cortes	Peru	Callao

Source: USAID/FFP



Photo - Food aid commodity infested with insects on arrival in-country. Evidence of boring damage and egg deposition apparent.

The **issue of fumigation** for USG food aid commodities has never been properly investigated by USAID, other donors, the UN or NGOs. The present USAID guidelines, as found in the Commodities Reference Guide (http://www.usaid.gov/our_work/humanitarian_assistance/ffp/crg/sec4.htm) are somewhat vague and variable. Different partners are using different approaches with varying degrees of sophistication that are not fully effective in ridding the food aid of insect pests. There is also a concern that some commodities may be exposed to "too many" fumigation cycles although it is unclear if this practice is dangerous or not.

Furthermore, USDA and FFP partners have had to destroy many hundreds of MT of commodity in recent times due to infestation. Disposing of large quantities of spoiled or contaminated food aid is an environmental management challenge itself. The PEA will set standards and provide guidelines as to what is and is not allowed for fumigation. Further, there should be a system that tries to identify where the infestation occurred and what measures should be undertaken to minimize future episodes.

Integrated Pest Management—USAID Best Practices: In addition to these pesticides, there is a range of closely associated integrated pest management and commodity management practices which when well executed serve to decrease the incidence of pest infestations and safeguard the quality of food aid resources. The interplay between these practices and the use of fumigants should also be considered here as part of due diligence of best practices. Both IPM and fumigation practices may also take on more importance as local procurement of food aid commodities becomes more commonplace and food safety and quality challenges have to be met in country.

PURPOSE OF THE PEA

The official review and approval of this PEA will precipitate a careful implementation which is expected to allow those involved in the program, whether representing USAID or its Cooperating Sponsor partners, to achieve a series of objectives, to wit:

- The PEA will bring the PL 480, Title II program into overall compliance under the precepts of the Agency's environmental regulations;
- The PEA will identify the potential for adverse human health and environmental impacts and recommend mitigation and monitoring measure to counter them;
- In doing the above, the PEA will develop tools and guidance that will lead to safer fumigation procedures and thus safeguard food aid quality, protect human health and ensure against adverse environmental impacts; and
- Build capacity for best management practices related to food aid protection and fumigation among the full array of stakeholders involved in Title II food aid.



Photo – Storage facilities for food aid commodities are expensive infrastructure investments, even some of the temporary facilities such as the Rubb Hall storage warehouse. Clean and neat facilities and properly stacked commodities are the start of sound storage practices and key to integrated pest management.

OUTCOME OF THE SCOPING EXERCISE

Scoping Exercise Methodology

The Scoping Exercise has been largely undertaken by an ENCAP consultant, Thomas Catterson from IRG, with direction and insight also provided by Dr. Erika Clesceri, DCHA Bureau Environment Officer, USAID, and participation from Dr. Walter Knausenberger, Bureau Environment Advisor, AFR/SD (please see their brief biographical sketches in **Annex B**).

Literature Review—a Sharepoint Site: Following the guidance outlined for scoping environmental assessments in USAID’s environmental procedures (Reg. 216), this Scoping Exercise methodology was simple and straight-forward. To begin with, a special effort has been made to identify and compile the most relevant literature related to the protection and fumigation of food aid commodities. There is actually some very good information available and as it started to accumulate, FFP suggested that a “Community of Practice” Sharepoint site be established as a means for making it available to a wider audience and ensuring that it remained intact ready for the actual PEA which will take place later this year. The intention is to eventually share this site with a wider stakeholder audience (<http://encap.sharepoint.af-sd.org/envofficers/fumigationpea/default.aspx?>). Please contact Erika Clesceri, DCHA/BEO to request access. A primary reference list drawn from the Sharepoint site is included here as Annex C.

Consultation—the Key to Environmental Assessment in the US:

The most important methodology for this Scoping Exercise, and something that will also feature prominently during the PEA itself, was consultation with the stakeholders. This began with consultations with in-house USAID staff in Washington involved in food aid programs. The Scoping Team was also favored by support from the staff of the FFP Advisory Support Project based at AMEX International who graciously assisted in organizing meetings with the Working Groups of the Food Aid Consultative Group. Member of three of the Working Groups—1) Packaging, 2) Food Aid Safety and 3) Quality Assurance, and Transportation—came together in Washington for half-days discussions with the Scoping Team during the week of April 18-22, 2011. The names and positions of the staff participating in these consultations can be found in Annex D.

These consultations took place in Washington and were so useful that the Scoping Team decided to widen its reach and sent out a follow-up questionnaire to all member organizations of the FACG and to USAID Mission FFP and Environment Staff. The list of those who responded is provided in Annex E and the questionnaire itself as sent can be seen in Annex F.

Draft Statement circulated for review: This document was circulated in draft for review and the comments and suggestions received have been incorporated into this final version. As is required, it is being submitted for official review and approval in anticipation of the scheduling of the actual Programmatic Environmental Assessment (PEA) later this year.

THE POTENTIAL FOR ADVERSE ENVIRONMENTAL IMPACTS

A careful consideration of the interplay between the announced activities being planned and the environmental sensitivities found at a given site where food aid commodities are stored and fumigated was made to develop a preliminary list of the potential adverse impacts. This analysis will consider environmental impacts to in potential impacts to both natural resources and the humans. This analysis also builds upon the issues raised during the consultations and in reviewing the relevant literature. The following issues were

Food Aid Tonnage (in million metric tonnes) by Fiscal Year:

Fiscal Year	Total Million Metric Tons
2002	2.834
2003	3.716
2004	1.504
2005	1.647
2006	1.653
2007	1.372
2008	N/A
2009	N/A
2010	N/A
2011	0.949

Source: USDA/USAID Global Humanitarian Food Aid Risk Assessment Summary (FY 2007) & USAID/FFP Data Base Printouts.

identified and are considered central to a well-focused programmatic environmental assessment (PEA) of food aid protection and fumigation activities as currently practiced within the Title II Program.

- **Human health impacts from direct exposure to toxic or poisonous gases:** Fumigation gases affecting warehouse facility workers, fumigant applicators and/or cumulative effects of gases escaping to affect neighbors of the warehouse?
- **Contamination of food aid with pesticides or negative impacts on food aid quality and safety:** Is there such a thing as too much fumigation (especially of concern is aluminum phosphide) of food aid commodities? Does grain or food aid lose quality or become contaminated with hazardous chemical residues if fumigated too many times? Are some food aid commodities more sensitive to quality losses as a result of either pest infestations or repeated fumigation? What about the direct application of Actellic (Perimiphos-Methyl) dust into grain commodity, which is often proposed for controlling post-harvest storage loss of local farm produce?
- **Issues of human health risk assessment for vulnerable populations:** Are vulnerable populations that Title II program serve such as lactating women, children under two, chronically malnourished more susceptible to neurological or immunological impacts of exposure to pesticide residues associated with commodity protection? What about bioconcentration of pesticides in mother's breast milk and exposure infants through exclusive breast feeding? Issues of concern with dose-response curves for under twos vs full sized adults, given body burden per mass is higher?
- **Confusion about pesticides intended for use in sanitizing warehouse facilities and grounds:** Pyrethroids are commonly applied for crack, crevice, and spot spray treatment in and around the empty warehouse. However, some Deltamethrin or Cypermethrin synthetic pyrethroids, are being applied improperly on food aid commodities and contaminating them.
- **Pesticides inadvertently dispersal from the warehouse site:** Pesticide residues affecting people and/or the environment and how...what pathways? Pesticide residues tracked out of warehouse from normal in/egress or from sweeping residues out the doors of commodity storage area? Contamination of ground waters associated with dissolution of water-soluble pesticide residues in rainfall runoff?
- **Dangerous solid wastes mis-managed:** Other treatment residues—contaminated/toxic residues or solid wastes associated with fumigation and how to dispose of them? Disposal of empty containers or sachets?
- **Dangers associated with other kinds of pesticide use associated with food aid commodity protection:** How do rodenticides differ, are we considering them here, what about the disposal of the rats killed due to pesticide exposure? Insecticides used to rid the warehouse space of potential pests; what precautions and are these residues coming in contact with food?
- **Fumigation may not be enough or ineffective:** Is fumigation fully effective for the intended target pests or are some insect pests or food aid quality issues not being satisfactorily addressed? What about the effectiveness of phosphine gas on control of fungal contamination mycotoxin (i.e., aflatoxin, etc.) contamination of food aid commodities?

ISSUES EXCLUDED FROM FURTHER CONSIDERATION

- Inappropriate risks associated with pesticide use: Are they using banned pesticides for fumigation purposes and if so, why? This matter is not considered significant because it is understood that the use of Methyl Bromide, now prohibited because of its negative impacts on the ozone layer, has been banned from fumigation programs worldwide.
- Post Harvest Storage loss in FFP Development Programs is a related topic but beyond the scope of the present PEA. FFP may wish to consider working with the Bureau for Food Security to address post harvest loss, either as a separate PEA or general program study in the context of the broader Feed the Future (FtF) initiative.

- Disposal of Spoiled Food Aid Commodities is another closely related issue but one that will require separate and concerted attention beyond the means of the planned PEA.
- Food Aid Quality as a broader issue will not be considered here because pest infestation is only a small part of the wide range of characteristics currently being considered as part of an effort to enhance food aid quality. See for example the May 2011 GAO Food Aid Quality report.

A CONSIDERATION OF ALTERNATIVES

The provision of safe and quality food aid commodities to people in need around the world does not brook any compromises about infestation. Safe food is a basic human right. At the same time, however, it is USAID policy and regulation to protect the environment which provides goods and services for basic human needs and ecosystem function and also to use pesticides only in the context of an integrated approach to pest management. Anything that can increase the provision of clean, dry storage will go a long way to reducing the propensity for pest infestations. Several alternatives to reduce fumigation using toxic pesticides are being considered and studied, both in terms of cost and effectiveness, focusing on those approaches that could either be used immediately or feasibly commercialized within 3-5 years; they include:

- **Tiered pesticide application approach:** Lower toxicity pesticides applied first as a preventative measure, with higher toxicity pesticides like aluminum phosphide applied only if needed based upon observation and data collected, not simply as a matter of routine and time schedule.
- **Entolation of milled wheat** practice prior to shipment, (USAID OAA, Denise Scherl, communication).
- The use of **hermetically sealed bags** for shipping food aid commodities to ensure that they are not subject to attacks by pests once bagged. (USAID FFP, Judy Canahuati, communication) Add Nigeria and Purdue Univ study.
- **Diatomaceous earth** as grain protectants at community food aid distribution points for relatively inexpensive and safe method of storage insect control.
- Use of **naturally-occurring products** for protection such as black pepper, coconut oil
- Application of non-solid phase or liquid chemical, **alternative treatment** such as heat treatments, irradiation, and inert gases like CO₂.
- Greater use of **genetically modified organism (GMO)** commodity which would be more resistant to insect infestation of food commodities due to a greater durability of grain germ reducing opportunities for infection by pest agents.

RECOMMENDATIONS AND DRAFT SOW FOR THE PEA

Engaging the Stakeholders

The Programmatic Environmental Assessment (PEA) being planned here to examine the potential for adverse human health and environmental impacts from food aid commodity protection and fumigation should have a profound effect on these activities over the years to come. Given the magnitude of the Title II Program, it is recommended that a small working group within FFP (and possibly including other USAID Bureaus) be assembled to sponsor, monitor and to work in support of the Bureau Environment Officer (BEO) of DCHA to eventually act upon the findings of the PEA.

It has also been suggested that this Scoping Statement be presented to the Executive Committee of the Food Aid Consultative Group at their upcoming (Oct. 2011) meeting for their consideration and to raise the profile and support for this important environmental management undertaking.

¹ Swella G.B., Mushobozy D.M.K. (2007): **Evaluation of the efficacy of protectants against cowpea bruchids (*Callosobruchus maculatus* (F.)) on cowpea seeds (*Vigna unguiculata* (L.) Walp.)**. Plant Protect. Sci., **43**: 68–72. <http://journals.uzpi.cz/publicFiles/00299.pdf>

PEA Team Configuration – Recruitment and Contracting of a Multi-disciplinary Environmental Assessment Team

This Scoping Statement would propose an EA team made up of the following positions/disciplines:

- **Team Leader/Environmental Review Specialist:** The overall duties of the Team Leader will be to oversee the design and implementation of the EA, participate in the detailed planning of the EA and, as possible, the selection of the candidates for other team positions, and coordinate the roles and inputs required of the other members of the Team. Additionally, the Team Leader will be the person responsible for interactions and communications with both USAID/FFP, any USAID Missions to be visited and the representatives of the Cooperating Sponsors. Finally, the Team Leader will be responsible for compiling and editing the report to be prepared by the team members as a result of this PEA (estimated LOE: 58 person-days).
- **Food Aid Commodities Management Specialist:** As noted elsewhere, the protection and fumigation activities are and should be part of a larger whole, a systematic process to deliver quality food assistance to those in need around the world. The complexities, process and rhythm of that process can easily affect how commodities are safeguarded and whether they need additional treatments. The role of this specialist will be to provide a sound explanation of the system and advise his/her team colleagues on the practicalities being recommended as mitigation and monitoring measures (estimated LOE: 50 person-days).
- **Food Grain Protection Specialist:** A full understanding of the proposed design and the range of activities entailed in safeguarding the quality and safety of food aid commodities will be critical to identifying cause and effect as concerns the potential for adverse environmental impacts, whether direct or indirect. This individual will work in close collaboration with the Team Leader to assess the potential for adverse impacts and to suggest mitigation and monitoring measures where required (estimated LOE: 50 person-days).
- **Experienced Fumigation Specialist:** Given the critical nature of the use of these toxic chemicals and pesticides as part of protection efforts, the PEA Team must be able to draw on the experience of someone who has had extensive real exposure and involvement in fumigating food aid commodities in different settings around the world (estimated LOE: 50 person-days).
- **Social and Environmental Impacts Analyst:** The basic premises of these food aid programs are that they will help to alleviate food security needs and opportunities in the area where they work and improve the nutritional status of the beneficiary community. Testing the social hypothesis that people are satisfied with the food aid programs from the perspective of food safety and quality will be essential to fulfilling the community dimensions of its sustainable design. This consultant will interview both community leaders and local stakeholders (staff of the CSs/NGOs and host government agencies) and the beneficiaries themselves about the premises of the food aid programs in which they are involved (estimated LOE: 50 person-days).
- **Mycotoxin/Alfatoxin Specialist:** It is usually assumed that fumigation is ineffective in dealing with mold and putative related mycotoxins², however additional evidence suggests phosphine gas as an alternative for controlling fungal growth and subsequent mycotoxin production³. This PEA represents a good opportunity to look at this issue and propose measures for increasing the understanding about it and how to mitigate it (estimated LOE: 10 person-days).

IMPLEMENTATION PLANNING AND EXECUTION – SOME PRACTICALITIES

Organizing an Effective and Efficient Series of Field Visits: Because of the almost global breadth of the Title II Program, a selected set of field visits must be carefully chosen to ensure that a fulsome range of the

² **Commodity Reference Guide, Section IV: Controlling Damage to Food Commodities, January 2006,**
http://www.usaid.gov/our_work/humanitarian_assistance/ffp/crg/sec4.htm

³ Castro M, Mills K. Phosphine: an alternative for controlling fungal growth and to avoid mycotoxin production in high-moisture stored grains. [serial online]. 2003; Available from: CAB Abstracts 1990-Present, Ipswich, MA. Accessed June 24, 2011.

activities and circumstances under which they take place are included in the data collection and analysis. The PEA Team should visit country programs including both relatively small and well organized program countries and also some of the more difficult circumstances under which food aid is stored up-country. Then too, two or three visits to select pre-positioning warehouse facilities are also foreseen.

It is tentatively proposed that two country program visits in Eastern and Southern Sub-Saharan Africa (possibly Kenya and Zimbabwe) including from primary warehouse (Mombasa) to community distribution points. In addition, travel to the port of Jacinto (Houston) may be involved. Finally, if time and resources allow, a visit to the port of Chittagong in Bangladesh and/or to the FFP program in Haiti may also be programmed. The duration of each country/pre-positioning site visit will depend on the extent of the travel required to see the targeted warehouse and food aid handling sites. Six day work weeks while on TDY are foreseen although typically the sixth day may be used by the Team itself for either travel or for internal discussions and analysis of the data and information they have collected.

PEA IS NOT AN EVALUATION

The PEA is not critical evaluation of current practices but an effort to obtain a current overview of the state of the art and practice globally. Key outcome is to learn from practices and prepare guidance for ensuring the continuing safety and quality of food aid commodities within the system.

Consultations with Local Stakeholders, USAID Missions and the Cooperating Sponsors:

As has been noted throughout this Scoping exercise, the PEA is not a critical evaluation of current practices but rather an effort to obtain a current overview of the state of the art/practice globally, and to learn from existing practices and practitioners and make suggestions and prepare guidance for ensuring the continuing safety and quality of food aid commodities within the system. It is foreseen that the FFP Office in Washington will ask its staff in the field to explain the objectives of the PEA Team mission to the USAID/Mission, Host Government personnel who may be involved and the Cooperating Sponsors and their local NGO partners. These FFP Staff in-country will organize the field visits so as to be able to see both primary and secondary storage facilities, consult with staff responsible for food aid commodity management and some representatives of the beneficiary community.

The Team Leader will develop a protocol providing a structured format for in-country data and information collection which allows all team members to address the areas of their specific interest while still facilitating effective interchange and reporting.

Proposed Timing and Dates of the PEA: The following parameters for the PEA are foreseen:

- The present plan assumes a start date for the PEA in October 2011 with a total duration of approximately 10 weeks depending on Mission and CS concurrence for visits.
- The PEA Team will assemble and carry out a virtual team building exercise under the direction of the Team Leader and the BEO/DCHA over a three week time period, with an approximate total LOE for the team building of one person week per team member.
- Once the countries and programs to be visited have been determined, the PEA Team will engage in a one week preparatory desk study and review of the Scoping Statement for each country. Two country visits in Sub-Saharan Africa are foreseen.
- The PEA Team will undertake a two week tdy to each selected country, one each in Eastern and Southern Africa, and visit food aid storage facilities from primary warehouses to up-country community oriented storage.
- Upon completion of the country visits, the PEA Team will spend three weeks each synthesizing and reporting on their findings, following the annotated outline of the PEA Final Report, in close collaboration and communication with the PEA Team Leader.

Pre-Departure Preliminary Debriefing: The PEA Team will be expected to provide a pre-departure debriefing for USAID and representatives of the Cooperating Sponsors to present their preliminary observations about the findings in the targeted country, and to seek comment and clarification as necessary.

Preparation of an Annotated Outline of the PEA Report: At some point along the way, the Team Leader will conference with his/her team members to develop an annotated outline of the eventual PEA Report. This outline will adhere to the guidance provided in Reg. 216 about the required elements of an EA Report although it is likely that additional guidance and tools will be developed in the course of this PEA.

The draft Annotated Outline will be circulated to the FFP Officer in charge of the PEA and any other USAID colleagues who she/he may designate to review it. The intention is to conclude the field visits with an agreed annotated outline in hand with specific drafting responsibilities understood and assigned to different team members. The Team Leader will work with the other team members to establish a rational timetable for the presentation of draft sections of the PEA Report.

Preparation and Review of the Final Report of the PEA: The following steps and timing are foreseen for the preparation and review of the Final Report of the PEA:

- The first draft will be due one month after the end of field visits, to be submitted by the PEA Team Leader to the BEO/DCHA.
- After preliminary scrutiny by the BEO, the draft will be circulated for review among members of the staff of FFP, the Regional Bureau BEOs and the BEO of the Bureau of Food Security.
- Cooperating Sponsors and WFP staff designated as stakeholders as part of the PEA process will receive a copy of the amended draft two weeks after the internal USAID review sessions are completed.
- The final timing of the production of the PEA Report is foreseen for the month of January 2012 noting that there may be a bit of a hiatus during the holiday season.

ANNEX D. BIOSKETCHES OF CORE PEA TEAM MEMBERS

Karen Menczer served as Team Leader/Environmental Review Specialist. She has a B.S. in Biology and an M.S. in Ecology, and did research for a Ph.D. (ABD) in Galapagos, Ecuador. Currently she is an independent consultant, focusing on environmental impact assessment and biodiversity conservation for USAID and its partners. From 1991-1997, she worked in USAID/Latin America and Caribbean Bureau as Natural Resources Advisor and also served as the Bureau Environmental Advisor. From 1997-2007, she lived in Uganda, Jamaica, Botswana, and Ghana, first working directly for USAID/Uganda as a Natural Resources Advisor and Mission Environmental Officer, and later working as an independent consultant. Upon returning to the US, she worked for The Cadmus Group, preparing EIA guidance, course material, and conducting environmental reviews for USAID/Washington and USAID missions. She has served as Team Leader on several USAID EAs and PEAs; and as Deputy Team Leader of the Millennium Challenge Corporation Strategic EA for its Namibia Compact, overseeing the work of a 22-person team.

Dr. Bhadriraju Subramanyam served on the PEA Team as the Food Grain Protection and Fumigation Specialist. He has M.S. and Ph.D. degrees from the University of Minnesota, and is currently the Don Wilbur Sr. Professor of Postharvest Protection in the Department of Grain Science and Industry, Kansas State University, Manhattan, Kansas. His area of emphasis for 30 years has been on protecting food and feed products from insect infestation throughout the supply chain using chemical and alternatives. He developed pest management programs for the food and feed industries, and helped companies develop insect resistant packing. In addition to stored-product protection, he teaches courses in food laws and food safety. As a member of the PEA Team, he interviewed stakeholders, inspected warehouses, provided information for human health risk evaluator's desk study, and wrote many sections of the PEA document on health and environmental risks associated with phosphine and alternatives.

Maureen A. Babu served as the Participatory Stakeholder Analyst and NGO Liaison in the PEA Team. She is trained as a Biologist and Urban Environmental & Infrastructure Manager (B.S. in Biology, The University of Nairobi, Kenya and an M.S. in Urban Management and Development, Erasmus University, The Netherlands). Additionally, she has training in strategic, environmental and social impact assessments. Since 2009, she has been working as an independent consultant on assignments ranging from policy review and regional framework development on environmental/social management, monitoring and evaluation of programs, program development and management to research. One of her current assignments includes working as part of a Team to develop an EIA framework for the IGAD member states. Prior to working as an Independent Consultant, she worked for amongst others (2003 to 2007), IUCN- International Union for Conservation of Nature, Eastern and Southern Africa as a Program Officer.

ANNEX E. PEA SCOPE OF WORK (EXCERPTS)

Attachment B: Detailed SOW

Scope of Work

Programmatic Environmental Assessment (PEA) for Title II food aid commodity protection and fumigation

Under the Global Environmental Support Project (GEMS)

I. Background. USAID’s Bureau for Democracy, Conflict and Humanitarian Assistance (DCHA) has tasked the GEMS project with undertaking a programmatic environmental assessment (PEA) for Title II food aid commodity protection and fumigation

Overall Technical approach/process. The PEA will fulfill the requirements of 22 CFR 216, with particular, but not exclusive emphasis on 216.3(5) and 216.6. It will, with the exception of the below-specified changes, be guided by the attached **PEA Scoping Statement** for Title II food aid commodity protection and fumigation, including important references and materials. (This scoping statement and other important references which may be useful in PEA preparation are also available on the Bureau for Africa SharePoint site at <http://encap.sharepoint.afr-sd.org/envofficers/fumigationpea/default.aspx>).

The exceptions and changes to the scoping statement are as follows:

- The PEA team and attendant LOE envisioned by the scoping statement has been revised
- A “Screening Human Health Risk Assessment on the Use of the Fumigant Phosphine Gas and its Primary Precursor Aluminum Phosphide” (HHRA) is being commissioned as part of the PEA.
- Timeline and travel/site visits have been revised as set out in this SoW.

II. Specific Objectives of the Assessment. Once reviewed and approved, this PEA will guide those involved in food assistance, whether representing USAID or its Cooperating Sponsor (CS) partners, to achieve a series of objectives. It will:

- bring the PL 480, Title II program into overall compliance under the precepts of the Agency’s environmental regulations;
- identify the potential for adverse human health and environmental impacts and recommend mitigation and monitoring measure to counter them;
- In doing the above, develop tools and guidance that will lead to safer fumigation procedures and thus safeguard food aid quality, protect human health and ensure against adverse environmental impacts; and
- build capacity for best management practices related to food aid protection and fumigation among the full array of stakeholders involved in Title II food aid.

III. Revised Team Composition.

Team Leader: To achieve the specific objectives above the Team Leader will:

- A. oversee the design and implementation of the PEA
- B. ensure all team members have carefully reviewed the Scoping Statement for the PEA, including the issues to be addressed and those to be excluded from consideration

- C. identify, and where feasible, seek to provide coverage for gaps in data or analysis, and revise team member SoWs, where appropriate.
- D. lead and coordinate interactions and communications with USAID/FFP, any USAID Missions to be visited, representatives of the Cooperating Sponsors, fumigation companies, and other stakeholders
- E. summarize concisely key impacts and programmatic recommendations and measures to mitigate adverse impacts and prepare the PEA environmental mitigation and monitoring plan
- F. provide a standalone summary document that will serve as guidance to CS's, USAID FFP staff, and other stakeholders on best practices in Food Aid protection and fumigation and IPM alternatives
- G. compile and edit the report sections prepared by the team members to ensure quality, completeness and uniformity in the draft and final PEA document
- H. lead the detailed planning of the PEA and coordinate the roles and inputs required of the other members of the Team.

Food Grain Protection and Fumigation/IPM Specialist: The specialist must have a full understanding of the proposed design and the range of activities entailed in safeguarding the quality and safety of food aid commodities and will identify potential adverse environmental and health impacts, whether direct or indirect; propose appropriate mitigation measures; and develop key elements of a programmatic environmental mitigation and monitoring plan. The specialist must be fully familiar with the state of the art literature on fumigation and IPM alternatives. The specialist will write key sections of the PEA on these impact and mitigation measures under the direction of the Team Leader. Given the use of toxic chemicals and pesticides as part of protection efforts, this specialist must have extensive real exposure and involvement in fumigating food aid commodities in different settings around the world. The specialist will also confer with and provide advice to the specialists preparing a separate Human Health Risk Assessment which is being conducted as separate desk study supplement to the PEA. In addition, fumigation is generally assumed to be ineffective in dealing with mold and putative related mycotoxins[1], however additional evidence suggests phosphine gas as an alternative for controlling fungal growth and subsequent mycotoxin production[2]. The specialist will look at this issue as well, and propose measures for increasing understanding and potential mitigation.

Participatory Stakeholder Analyst and NGO Liaison (PSA): The Participatory Stakeholder Analyst (PSA) and NGO Liaison (PSA) will be responsible for obtaining stakeholder views on potential social/health and gender impacts and their thoughts and recommendations on how to mitigate (minimize or avoid) those impacts. Under the direction of the Team Leader and in regular consultation with the Senior Social Impact Assessment (SIA) specialist, the PSA will: a) Identify and review the most current and appropriate literature on potential social/health and gender impacts and mitigation and monitoring measures related to food aid protection and fumigation; b) develop and apply a participatory stakeholder survey instrument for different stakeholder groups, including, but not limited to Cooperating Sponsors (CS's), community beneficiaries, FFP officers and staff, fumigation staff and fumigation company representatives; c) be responsible for writing key sections of the PEA on both the potential social/health and gender impacts and mitigation measures and the PEA environmental mitigation and monitoring plan; d) In addition to looking at impacts associated with current practice, help assess traditional methods for providing grain storage insect protection; e) be responsible for liaison with NGO's involved in food distribution and fumigation and for providing some logistic coordination for the team; f) seek regular advice and counsel from the SIA specialist throughout the PEA process; g) other tasks as defined by the Team Leader.

[1] Commodity Reference Guide, Section IV: Controlling Damage to Food Commodities, January 2006, [HTTP://WWW.USAID.GOV/OUR_WORK/HUMANITARIAN_ASSISTANCE/FFP/CRG/SEC4.HTM](http://www.usaid.gov/our_work/humanitarian_assistance/ffp/crg/sec4.htm)

[2] Castro M, Mills K. Phosphine: an alternative for controlling fungal growth and to avoid mycotoxin production in high-moisture stored grains. [serial online]. 2003; Available from: CAB Abstracts 1990-Present, Ipswich, MA. Accessed June 24, 2011.

Senior Social Impact Assessment (SIA) Specialist: The SIA Specialist will have a background in social/health and gender impact assessment and will mentor the PSA specialist on a regular basis throughout the PEA process, with special emphasis on helping guide the PSA to the most current and appropriate literature on potential social/health and gender impacts and mitigation and monitoring measures related to food aid protection and fumigation; b) help the SIA specialist and TL develop and apply a participatory stakeholder survey instrument for different stakeholder groups, including, but not limited to Cooperating Sponsors (CS's), community beneficiaries, FFP officers and staff, fumigation staff and fumigation company representatives; and review and comment on the SIA's written products.

Technical Quality Assurance/Quality Control Specialist: Pesticides/IPM and PERSUAP expert for QA/QC review.

IV. Screening Human Health Risk Assessment (HHRA). A "Screening Human Health Risk Assessment on the Use of the Fumigant Phosphine Gas and its Primary Precursor Aluminum Phosphide" (HHRA) is being commissioned as part of the PEA. This is a desk study with a separate SoW and LoE that will be initiated prior to the Team site visits and completed shortly after submission of the site visit report. Findings will feed into draft and final PEA results, recommendation and guidance.

VI. Implementation Planning and Execution

Organizing an Effective and Efficient Series of Field Visits: Because of the almost global breadth of the Title II Program, selected site visits will be undertaken to ensure that information collected through literature reviews and remote interviews are corroborated and supplemented by on-site assessment and stakeholder interviews and incorporated in the data collection and analysis process. The PEA Team will visit country programs including both relatively small and well organized program countries and also some of the more difficult circumstances under which food aid is stored up-country. Also foreseen are two or three visits to selected pre-positioning warehouse facilities.

Two country program visits in Eastern and Southern Sub-Saharan Africa (possibly Kenya and Zimbabwe) are proposed including from primary warehouse (Mombasa) to community distribution points. The duration of each country/pre-positioning site visit will be limited to one week for Kenya and one week for the Southern African location and will also depend on the extent of the travel required to see the targeted warehouse and food aid handling sites. Six day work weeks while on TDY are foreseen although typically the sixth day may be used by the Team itself for either travel or for internal discussions and analysis of the data and information they have collected.

Consultations with Local Stakeholders, USAID Missions and the Cooperating Sponsors:

As has been noted throughout the Scoping exercise, the PEA is not a critical evaluation of current practices but rather an effort to obtain a current overview of the state of the art/practice

globally, to learn from existing practices and practitioners, and to make suggestions and prepare guidance for ensuring the continuing safety and quality of food aid commodities within the system. It is foreseen that the FFP Office in Washington will ask its staff in the field to explain the objectives of the PEA Team mission to the USAID/Mission, Host Government personnel who may be involved and the Cooperating Sponsors and their local NGO partners. These FFP Staff in-country will organize the field visits so as to be able to see both primary and secondary storage facilities, consult with staff responsible for food aid commodity management and some representatives of the beneficiary community.

PEA IS NOT AN EVALUATION

The PEA is not critical evaluation of current practices but an effort to obtain a current overview of the state of the art and practice globally. Key outcome is to learn from practices and prepare guidance for ensuring the continuing safety and quality of food aid commodities within the system

The Team Leader with the PSA Analyst and the senior SIA Social Specialist will develop a protocol providing a structured format for in-country data and information collection which allows all team members to address the areas of their specific interest while still facilitating effective interchange and reporting.

VII. Proposed Timing and Dates of the PEA: The following parameters for the PEA are foreseen:

- The present plan assumes a **start date** for the PEA in December 2011 with a total duration of approximately 5 months depending on Mission and CS concurrence for visits.
- A one day **virtual team orientation** will occur in late December under the direction of the Team Leader and the BEO/DCHA. Two days of **preparatory desk study** and review of the Scoping Statement will occur prior to the team orientation and another two after the team has discussed the PEA Scope, for an approximate LoE of four person days per core team member for preparatory desk work and team building. The Food Aid Protection and Fumigation/IPM Specialist will submit a state of the art literature review to the TL prior to the late December team orientation.
- The PEA Team will undertake a **one week tdy to each selected country**, one each in Eastern Africa (Kenya) and Southern Africa (tbd), and visit food aid storage facilities from primary warehouses to up-country community oriented storage. The Team will be expected to provide pre-departure debriefings for USAID and representatives of the Cooperating Sponsors to present their preliminary observations about the findings in the targeted country, and to seek comment and clarification as necessary.
- Upon completion of the country visits, the PEA Core Team (TL, Food Protection/Fumigation Specialist and Participatory Stakeholder Analyst and NGO Liaison (PSA) will spend approximately three weeks each **synthesizing and reporting on their findings**, following the annotated outline of the PEA Final Report, in close collaboration and communication with the PEA Team Leader.
- **Preparation of an Annotated Outline of the PEA Report:** Within 4 weeks of startup, the Team Leader will conference with his/her team members to develop an annotated outline of the eventual PEA Report. This outline will adhere to the guidance provided in Reg. 216 about the required elements of an EA Report although it is likely that additional guidance and tools will be developed in the course of this PEA.
- **The draft Annotated Outline** will be circulated to the FFP Officer in charge of the PEA and any other USAID colleagues who she/he may designate to review it by **December 22nd, 2011**. The intention is to carry out the field visits with an agreed annotated outline in hand with specific drafting responsibilities understood and assigned to different team members. The Team Leader will work with the other team members to establish a rational timetable for the presentation of draft sections of the PEA Report.
- **Preparation and Review of the Final Report of the PEA:** The following steps and timing are foreseen for the preparation and review of the Final Report of the PEA:
 - The first draft will be due one month after the end of field visits, to be submitted by the PEA Team Leader to the BEO/DCHA.
 - After preliminary scrutiny by the BEO, the draft will be circulated for review among members of the staff of FFP, the Regional Bureau BEOs and the BEO for the Bureau of Food Security.
 - Cooperating Sponsors and WFP staff designated as stakeholders as part of the PEA process will receive a copy of the amended draft two weeks after the internal USAID review sessions are completed.
 - The core team will retain an additional one week to address and incorporate suggested revisions to the final document.

- The final timing of the production of the PEA Report is foreseen for the month of March 2012, noting that there may be delay as a result of the holiday season.

DCHA, Mission and Cooperating Sponsor (CS) Support. Successful execution of this SOW will require DCHA, mission and Implementing Partner support, as noted in the discussion of tasks above.

The nature and extent of mission and CS support will be determined in close consultation with DCHA and the Cadmus home office.

Locations: U.S., Kenya and Southern Africa.

Duration and Timing: 45 working days in total November to March 31, 2012, with site visits to Kenya and Southern Africa (9-23 January 2012.)

Total LOE: 45 days (5 days prep, 5 days transit, 12 working days on site visits, 18 days draft report preparation; 5 days integration of comments and final report preparation).

VIII. Deliverables: (1) prior to December 22nd, (1) a detailed draft PEA Outline, a draft site visit itinerary and team member responsibilities; (2) draft site visit report (within 5 days of return from site visits); (3) draft PEA report by 19 February 2012 and final PEA (within 10 days of receipt of final comments or 31 March 2012).

ANNEX F: LIST OF CONTACTS

Name	Organization	Title	Email address	Phone(s)
Manhattan, Kansas Study Tour, January 2012				
Thadd Bigler	Central States Enterprises	VP Inland Division	thadd@centralse.com	785-493-1587
USAID/Washington Stakeholder Consultations, January 2012				
Christine Karpinski	USAID/M/OAA/T	Traffic Management Specialist	ckarpinski@usaid.gov	202-567-4642
KD Ladd, RD	ACDI/VOCA	Technical Director of Nutrition Food Security	ladd@acdivoca.org	202-469-6228
Maria Tupac	ACDI/VOCA	Deputy Director of Commodity Management Food Security	mtupac@acdivoca.org	202-469-6257
Barry Elkin	ACDI/VOCA	Technical Director of Commodity Management	belkin@acdivoca.org	202-469-6091
Lang Hoyt	ACDI/VOCA	Project Assistant/Community Development	lhoyt@acdivoca.org	202-469-6257
Stella Siegel	ACDI/VOCA	Director of Environmental Compliance	ssiegel@acdivoca.org	
Byron Reilly	USDA Federal Grain Inspection Service	Grain Marketing Specialist, Office of International Affairs	Byron.reilly@usda.gov	202-690-3368
Anthony Goodman	USDA-GIPSA FGIS	Grain Marketing Specialist	Anthony.T.Goodeman@usda.gov	202-720-0291
Robert Sindt	U.S. Bean Council	Attorney	rsindt@bobsindtlaw.com	202-466-4500
Larry Sprague	Kelley Bean Co.	Senior Merchandiser	lsprague@kelleybean.com	989-288-7477
Bill Thoreson	North Central Commodities	Sales Manager	nccbill@polarcomm.com	701-869-2692

James Jones	World Vision	Program Management Officer-Integrated Food and Nutrition	jamjones@worldvision.org	202-572-6546
Yemane Kahssay	Catholic Relief Services	Senior Advisor, Commodity Management	Yemane.Kahssay@crs.org	410-951-7238
Frank Orzechowski	CRS	Senior Monetization Advisor, Overseas Support Department	forzecho@crs.org	410-951-7482
Lucas Shindeldecker	Food for the Hungry		lucas@fh.org	202-688-3567
Stephen Moody	USAID/FFP	Senior Advisor for Food Technology	smoody@usaid.gov	202-712-0768
Walter Knausenberger	USAID/AFR/SD/E GEA	Senior Regional Environmental Policy Advisor	wknausenberger@usaid.gov	202-712-4429
Greg Olson	USAID/FFP/POD	Program Analyst	golson@usaid.gov	
Aaron Reinhart	USAID/FFP/PTD		areinhart@usaid.gov	
Deirdre Lapin	African Studies Center University of Pennsylvania	Consultant, PEA Team Member	dlapin@verizon.net	202-244-5508
Telephone and Email Interviews				
Khawaja Adeeb	Save the Children	Deputy Director Commodity Management	KAdeeb@savechildren.org	203-221-3758
Paul Green		International Trade Consultant		202-488-3566
David Haysmith		Independent Consultant	davehaysmith@hotmail.com	
Rachel Vas	USAID/DCHA/FFP	Program Operations Specialist	rvas@usaid.gov	202-712-1666

Linda Bratt	Intertek Industry & Assurance Agri Services (Durban, South Africa)		linda.bratt@intertek.com	+27 (0)31 274 8000
Brandon Cummings	Intertek Industry & Assurance Agri Services (Durban, South Africa)	Agri Manager	Brandon.Cumming@intertek.com	+27 (0)31 274 8000
Thomas Catterson		Independent Consultant, author of PEA Scoping Statement	ThomasC782@aol.com	
John Martin	The Cadmus Group	Senior Scientist	john.martin@cadmusgroup.com	617-673-7176
Ralyea, Bridget	USAID/DCHA/FFP	East Africa/Horn Team - Ethiopia	bralyea@usaid.gov	202-712-5523
Norman Lidoff		Independent consultant Pest Management Specialist	nolidoff@hotmail.com	
Herb Yeaman	Degesch America		hyeaman@degeschamerica.com	Cell:540-421- 5449; office:540- 459-1858
Shelly Green		Independent Consultant Pest Management Specialist	sgreen@yahoo.co.uk	
Ted Rogers	USDA Office of Pest Management Policy	Biologist, Senior Policy Analyst	ted.rogers@ars.usda.gov	202-720-3846
UGANDA: Discussions facilitated by Maureen				
5 th April 2012- USAID briefing, meeting with Cooperating Sponsor(CS), warehouse visit				
Dianna Darsney de Salcedo	USAID Uganda	Vulnerable Populations Unit	ddarsney@usaid.gov	+2564143060 01

		Leader		
Sudi Bamulesewa	“	Team Leader, Environmental/Natural Resources Sub-Team	sbamulesewa@usaid.gov	“
Lawrence Oroma	“	Food Security Specialist, Vulnerable Populations Unit-Economic Growth Team	loroma@usaid.gov	“
Iven L.Ose	ACDI/VOCA	Program Manager/Chief of Party	iose@acdivocaug.biz	+2564143433 06/241-2
Agnes Namagembe	“	Logistics Assistant	anamagembe@acdivocaug.org	“
Edith Mary Asiimwe	“	Warehouse Officer	easiimwe-pl480@acdivocaug.org	“
10 th April 2012- meeting with CS and fumigation company				
Darius Radcliffe	MercyCorps	Country Director	dradcliffe@field.mercycorps.org	+2563122653 58,077403721 6
Benson K.	“	Warehouse Officer- Kitgum	bonekalif@ug.mercycorps.org	+2567826008 33
Lawrence Oroma	USAID Uganda	Food Security Specialist, Vulnerable Populations Unit-Economic Growth Team	loroma@usaid.gov	+2564143060 01
Maju Champlain	Supreme Fumigation Services Ltd	Operations Manager	majuchamplain@yahoo.com	+2567724681 87, 0782322070, 41254137
ETHIOPIA: Discussions facilitated by Karen, Subi and Maureen				
16 th April 2012- USAID briefing				
Scott Hocklander	USAID Ethiopia	Chief, Assets and Livelihoods in Transition Office	SHocklander@usaid.gov	+2511113060 02
Yitaye Abebe	“	Mission Environmental Officer	yabebe@usaid.gov	+2519111107 97, 111306601
Kenjit Eshetu	“	Resource Manager	keshetu@usaid.gov	+2519111081 89

17 th April 2012- meeting with CSs in Addis Ababa and warehouse visits in Adama, Nazareth				
Saikat Saha	Save the Children	Deputy Chief of Party	ssaha@savechildren.org	+2511137284 55 ext 195
Kassaye Yimer	“	Knowledge Manager, Title II Coordination Group	kyomer@savechildren.org , yimerkassaye@yahoo.com	
Leulseged Belay	USAID Ethiopia	Program Management Specialist, Assets & Livelihoods in Transition Office	lbelay@usaid.gov	+2511113068 31
Jason P. Taylor	“	Dep. Chief, Assets and Livelihoods in Transition Office	jtaylor@usaid.gov	+2511113066 03
Girma Deressa	Food for the Hungry/ Ethiopia (FHE)		gderessa@fh.org	
Tigabu Tarekegn	“	Commodity Manager	ttarekegn@fh.org	
Tesfaye Tilahun	Catholic Relief Services (CRS)	Program Manager, Food Security	Tesfaye.tilahun@crs.org	+2511127888 00
Jafar Mohammed	World Food Programme (WFP)	Logistics Manager	jafar.mohammed@wfp.org	+2511114032
Mohammed Elsayed Elhagfarah (Kamal)	“	Programme Officer & Head, Nazareth sub-office	Kamal.elhagfarah@wfp.org	+2512211140 32
Tsegaye Tigist	Save the Children warehouse in Nazareth	Warehouse Manager	Tsegaye.tigist@wfp.org	+2519113774 97
Yosef Digare	“	Commodity Supervisor	Yosef.dogare@wfp.org	
Gulilat Debebe	“	Fumigation expert	Debebe.gulilat@wfp.org	
18 th April 2012- warehouse visits, CSs and community beneficiaries representatives interviews in Adama (Nazareth)				
Negassi Jemaneh	Catholic Relief Services (CRS)	Coordinator	njemaneh@crs.org	+2519112487 17
Tefeli Tilahun	“	Store Keeper		+2519119256 86
Bisrat Wolde	“	Warehouse Supervisor	bisratwolde40@yahoo.com	+2519117619 53
Asrat Abera	“	FHE warehouse		

		assistant store keeper		
Teshome Tesfaye	MCS- Wonji Project Area/ CRS- Ethiopia (Community beneficiaries sites)	Senior Natural Resources Management (NRM) and commodity expert	teshomet2003@yahoo.com	+251911797747
Shiferaw Dugassa	“	Commodity Supervisor		+251911759148
Simon Bekele	“	Driver		+25191176417
19 th April 2012- meeting with pest management/fumigation and transport companies at Save the Children/ USA, Addis Ababa				
Kassaye Yimer	Save the Children/USA	Knowledge Manager	kyimer@savechildren.org	
Saikat Saha	“	Deputy Chief of Party T2FS-DFAP	ssaha@savechildren.org	+251930014022
Walter Mwasaa	“	Chief of Party- Transformation to Food Security (T2FS) Programme	wmwasaa@savechildren.org	+251113728455
Tebila Worbu	“	Administrator Manager	tworbu@savechildren.org	+251911211053
Leulseged Belay	USAID	Programme Management Specialist	lbelay@usaid.gov	+251111306831
Teferha Teshome	Star Pest Control	General Manager	starpest@ethionet.et	+251911212675
Tigabu Tarekegn	Food for the Hungry	Commodity Manager		+251911629469
Ayela Belachew	Smayaz Transact International	Managing Director	smayaz@telecom.net.et	+251911206411
Abiy Sahlemarlian	Zollo Pest Control	Managing Director		+251911230262
Heinlolen Olona	Gibe Freight Transporters	Board Chairperson		+251911216341
Tewedros Dabela	Tedy Ethiopia Transporters	General Manager		+251911220808
Mekasha Tsegaye	Hebret F.T.O.A	General Manager		+251912446170
Ashebiri Nigussie	Atlantic F.T.O.A	Freight Manager		+251911237042

Ersca Hlmaian	“	General Manager		+251911182490
Tizazu Mengisti	Semen F.T.O.A	Manager		+251911205831
Anemaw Asmanau	Ayal Tizazu P.F.T	Manager		+251930011912
Genet Gebre	Compass Transport	Transport Coordinator		+251911452076
Teulodres Bethanu	Tared Transport	Transport Coordinator		+251913067893
19 th April 2012- Debrief session at CRS , Addis Ababa				
Leulseged Belay	USAID	Programme Management Specialist	lbelay@usaid.gov	+251111306831
Wase Guben	USAID	“	wgubene@usaid.gov	
Tigabu Tarekegn	Food for the Hungry/ Ethiopia (FHE)	Commodity Manager	ttarekegn@fh.org	
Saikat Saha	Save the Children/USA	Deputy Chief of Party T2FS-DFAP	ssaha@savechildren.org	+251930014022
Kassaye Yimer	“	Knowledge Manger	kyimer@savechildren.org	
Carlos Sanchez	CRS	Head of Programme	Carlos.sanchez@crs.org	
Negassi Jemaneh	“	Coordinator	njemaneh@crs.org	+251911248717
Tsega Berhame	“	Deputy Logistics Manager	tsega.berhame@crs.org	
Tesfaye Tilahun	“	Program Manager, Food Security	Tesfaye.tilahun@crs.org	
Siraj Getahun	“	Deputy Head of Programme	Siraj.getahun@crs.org	
Rich Markowski	“	Chief of Party, Ext JEOP	Richard.markowski@crs.org	
Getahun Seife	“	Compliance Manager	Getahun.seife@crs.org	
20 th April 2012- Debrief at USAID with ALT Office (food commodity monitors), Addis Ababa				
Wase Guben	USAID	Program Management Specialist	wgubene@usaid.gov	
Leulseged Belay	“	Programme Management	lbelay@usaid.gov	+251111306831

		Specialist		
Reshid Abdi	“	Senior Program Management Specialist	rabdi@usaid.gov	
Muna Bayou	“	Resource Analyst	mbayou@usaid.gov	
Jason Taylor	“	Dep. Chief, Assets and Livelihoods in Transition Office	jtaylor@usaid.gov	+251111306603
Yacob Wondimkun	“	Environment & Natural Resources Specialist	ywondimkun@usaid.gov	
20 th April 2012- Meeting with WFP fumigation experts at the Hilton, Addis Ababa				
AbduSultan Sherif	WFP	Senior Logistics Assistant	Abdusultan.sherif@wfp.org	+251911655761
Henock Tefera	“	Logistics Assistant	Henock.teferra@wfp.org	+251911317574
DJIBOUTI: Discussions conducted by Karen, Subi and Maureen. Hany Elabe of USAID Djibouti attended all the meetings				
23 rd April 2012- Warehouse visits, meeting with CS, surveyors, fumigation companies and the Djibouti Port (grain and fertilizer terminal) officials				
Hany Elabe	USAID Djibouti	Procurement & Food for Peace Assistant	HANYYS@state.gov , hanyelabe@gmail.com	+253858381
Jaysen Toocaram	BMMI Djibouti	Finance Manager	jtoocaram@bmmi.com.bh	+253650476
Richard Otieno	Intertek	Surveyor-Agri. Services	richard.otieno@intertek.com	+25321359283, 077846952
Sergio Monteiro	WFP	Head of Logistics, WFP Djibouti Port Operation	sergio.monteiro@wfp.org	+253355257, 0848398
Samatar Ismail	Red Initial (fumigation company- currently contracted by WFP)	Fumigation worker	Redinitial@intnet.dj	
Elayefi Omar	“	“	“	
Abdourama	“	“	“	
Eric Eusebio	Société Djiboutienne de Gestion du Terminal Vraquier (SDTV) FZE- Port	Safety Manager	eric.eusebio@sdtvdjibouti.com	+25321358277, 21358276

	clearance operations			
Peter Were Ogal	“	Operation Manager	peter@sdtvdjibouti.com , werep2@yahoo.com	“
Moussa Ahmed Mohamed	“	Deputy Operation Manager	moussa.ahmed@sdtvdjibouti.com	“
Mahesh Kumar S.	Allied Survey and Testing (Port terminal inspectors)	General Manager	mahesh.kumar@gsk-group.com	+25377819463
K. Prakash	“	Cargo Surveyor	prakash.k@gsk-group.com	+25377639603
Bedassa Olana	Technical Director	Djibouti Pest Control	lemuketi2012@gmail.com ,	+25321353444, 077646330
Said Omar Moussa	General Manager	“	said@intnet.dj	+25321353444
24 th April 2012- Warehouse visit, meeting with surveyors and transport company				
Vinay Guddye	GSK Group	Group Business Development Manager	vinay.guddye@gsk-group.com	+25377805123, 21353844
Capt. Pawan Datta	“	Business Development Director	capt.datta@gsk-group.com	+253810787, 353171
Shaik Fareed Basha	General Transport Services (GTS)- Marine & Cargo Surveyors	General Manager	sheik.fareed@gsk-group.com	+253835555, 340118
Mahamoud Daher God	“	Jr. Surveyor	mahamoud.daher@gsk-group.com	+253832704, 340118
Waberi Houssein Djama	Global Maritime Surveyors- Cargo, Marine & insurance	Surveyor/ Operation Manager	waberigms@intnet.dj , globsurv@intnet.dj	+253251170, 351451
P.R. Nair	“	Principal Surveyor	prnairgms@intnet.dj , globsurv@intnet.dj	+253251170, 351451

ANNEX G. PEA RESEARCH QUESTIONNAIRE FOR FIELD WORK, APRIL 2012

a) Cooperating sponsors

1. At what point does your organization take responsibility for/control of the food aid commodity?
 - What type of food commodity do you receive?
 - What criteria do you use to release food aid commodity before accepting/receiving it?
 - Have you had any issues with the food consignment when it arrives (*i.e. the condition of the commodity*)?
 - o What actions did you take to address these issues?
 - From the time you receive the food aid commodity, how long does it take before it is distributed to the beneficiaries?
2. Where is the food aid commodity warehoused once you receive it?
 - How long does it stay at the primary warehouse?
 - Who is responsible for monitoring the condition of the food commodity at the warehouse?
 - o How is the monitoring done?
 - What happens if you find out that food commodity is infested?
 - What do you do to prevent infestation for food commodity? (*Describe the typical Integrated Pest Management (IPM) practice that your organization uses for food aid commodity protection*)
 - Of the pest insects, rodents, birds and moulds, which is your biggest problem?
 - If you have a problem, who makes the decision that food commodity is fumigated and how is this decision reached/made?
 - What criteria do you use to select the fumigation service providers? (e.g. trained, licensed to operate etc) (*request for a copy of the service contract*)
 - Do you have your own staff on site to monitor the fumigation process?
3. How do you transport the food commodity from the primary warehouse to the secondary and tertiary warehouses?
 - Do you rent or own the transport carriers?
 - Do you inspect the trucks before food commodity is loaded?
 - o What inspection criteria do you use (do you have a standard operating procedure (SOP) for inspection)
 - Do you practice in-transit fumigation?
 - o How is this conducted?
4. What concerns do you have about:
 - (a.) fumigation ?
 - (b.) the fumigated commodity?
5. What concerns do your beneficiaries have with regards to food aid commodity?
6. Do you know what happens before the food commodity arrives at the discharge port?
7. Do you have any suggestions for improving food aid commodity protection?

b) Warehouse/silo/ food storage facilities workers and their supervisors

1. Describe your food aid commodity receiving practices (*inspections at port or warehouse etc*)
 - By what mode of transport does food commodity arrive at the warehouse?
 - How do you manage your inventory?

- How do you manage the discharge of food aid commodity from the warehouse? (*e.g. FIFO practice at the warehouse*)
 - How do you store bagged food aid commodity in the warehouse? (*e.g. stacked on pallets lined underneath with plastic paper*)
 - What is the maximum height of the bagged food commodity stacks?
 - How do you store the different types of food commodities (*e.g. segregation by commodity, risk of infestation*)
 - How do you maintain cleanliness of the warehouse (sanitation practices)?
 - Who makes the decision on commodity protection? How is the decision made? (*what is it based on?*)
2. What is the turnover rate of food commodity in the warehouse?
 3. Who is responsible for monitoring the condition of the food commodity at the warehouse?
 - How is the monitoring done?
 - What steps do you take for commodity protection? (*What are your IPM methods used?*)
 4. Do you have your own warehouse staff trained in pest identification and management?
 - Do you self-apply pesticides?
 - What safety procedures are observed? (*e.g. Personal Protective Clothing*)
 - What are the specific training and certification requirements that you adhere to?
 - Is any staff trained and certified to apply fumigants?
 - Do you store any chemicals on site?
 - What are your chemical storage procedures?
 5. If fumigation is done, describe the fumigation process/practice adopted by the warehouse (*request for a printed protocol*)
 - How do you fumigate food aid commodity? (*e.g. entire stack in the warehouse or a portion*)
 - Once you open a flask of tablets do you use all of it?
 - What fumigant formulation is applied? (*Request for a copy of the label, Material Safety Data Sheet*)
 - What dosage is applied and what guides the decision on amount, time for the fumigation process etc to be considered?
 - Do you monitor the fumigation process when in progress?
 - How do you monitor gas concentrations?
 - What safety precautions do you take during fumigation?
 - How do you know when to fumigate or use other pesticides?
 - What are your major pests of concern?
 - Do you use rodent bait stations?
 - What rodent baits do you use?
 - How do you dispose off dead rodents?
 - Do you have issues with moulds in food aid commodities?
 - What actions do you take to address this?
 - What difficulties have you noticed with respect to food aid commodities
 6. Which of the commodities is more susceptible to infestation by insects and/or rodents?

c) Fumigation companies: workers and supervisor

1. Where is your work based? (*In the city or elsewhere*)
2. How were you selected as a contractor to conduct fumigation?
 - How many people perform a fumigation operation?
 - What does each individual do?

- How long does it take to cover stacks with sheets and put sandbags?
 - How many times per month (or per year) is fumigation performed?
 - For how long are commodities typically fumigated?
 - Do workers enter the structure as fumigation is on-going?
 - How many years have the workers been conducting fumigation?
 - For how many years do workers generally perform fumigation?
 - o Do fumigation workers also apply other pesticides?
 - What training is offered to workers? (*Qualifications and continued education*)
 - What risks are you concerned about during fumigation?
 - Have there been any incidences while using fumigants?
3. What services do you provide during your warehouse visits?
4. What products are used by your organization for fumigation? *-(Request for a copy of the label, Material Safety Data Sheet)*
- How do you know when to fumigate or use other pesticides?
 - What are the other pesticides used? (*label and MSDS*)
 - Do you apply any pesticides to warehouse floors and walls?
 - Do you apply pesticides to surfaces of bags on pallets?
 - How are the stacks to be fumigated prepared before fumigation?
 - o What is the fumigation dosage that is applied? (*2-3 tablets/ton or 1-1.5 g/m²*)
 - Do you fumigate all the food stacks in the warehouse or a portion of it?
 - o If a portion is treated, is the warehouse open for workers to enter to perform cleaning or maintenance work?
 - What safety measures are taken during fumigation?
 - o How is this communicated to the (illiterate) employees?
 - Describe your adopted fumigation process/practice (Before, during and after). Is there a standard operating procedure or practices that you follow? *-request for a written protocol*
 - What is the typical fumigation length in days?
 - How do you measure gas concentrations (during and after a fumigation)?
 - How do you determine gas tightness of the commodity under tarps? (*Do you do a pressure test?*)
 - How do you know you have a gastight enclosure during fumigation?
 - What smell gives you an indication of gas leakage through tarps?
 - Describe your fumigant residue retrieval and disposal practice? (*do you deactivate residue in water or do you bury it in the ground?*)
 - o If you bury the residues, how far from the warehouse do you bury it and how deep?
 - How do you dispose of pesticide's packaging/container and expired pesticides specifically fumigants?
 - How long is the aeration or fumigant clearance period after fumigation?
 - How many hours are spent by the fumigation worker in the structure as ventilation is being prepared (removal of tarpaulins, etc.)?
 - How do you know when it is safe to re-enter the warehouse after ventilation?
5. What constitutes an effective fumigation process?
- How long does it take before the next fumigation assignment at the same warehouse?

d) Transportation companies

1. What modes of transportation do you provide? (*railcars, trucks, other means*)
 - Do you own or lease transportation carriers?
2. How do you prepare the carrier prior to loading food aid commodity? (*Disinfestations procedures, if any---request of the company's written procedures*).

3. Do you inspect food commodity to check for infestation before loading?
 - Where do you look for infestation (*floor-wall junctions*)
 - What actions do you take if infestation is noted?
4. Do you also use your trucks to transport non-food commodities?
 - o Please indicate the non-food commodities?
5. During transportation, how do you protect the food aid commodity from weather conditions (e.g. rain)?
6. When transporting food aid commodity, do you carry other non-food materials along?
7. What is the average time taken for transportation of food aid commodity?
8. What issues have you faced while transporting food aid commodity?
9. What is your opinion on in-transit fumigation, if it is practiced?

e) Community beneficiaries

1. What types of food aid commodity do you receive?
2. From where do you collect the food aid commodity?
3. Describe the general condition of the received food aid commodity (*e.g. clean, dry, smelly, moldy, infested etc.*)
4. Are you satisfied with the quality of the food commodity? (*from the useability standpoint*)
5. Describe any incidences where the food commodity may have been of poor condition
 - What actions did you take?
 - How was this communicated back to the distributors?

ANNEX H: US REQUIREMENTS TO OBTAIN CERTIFICATION TO USE RESTRICTED USE PESTICIDES

The following information is revised from:

<http://www.epa.gov/agriculture/lfra.html#Restricted%20Use%20Classification%20and%20Certification%20of%20Applicators>;

<http://www.ag.ndsu.nodak.edu/aginfo/pesticide/subpages/guidePesticideCertification.htm>

Pesticide certification is required by the United States Environmental Protection Agency (US EPA) for people selling, purchasing, or using restricted use pesticides (RUPs). The regulation is under the 1947 Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) Part 171. Requirements listed in Part 171 are intended as a minimum and set a federal standard from which US states can develop their own. Many states have incorporated stricter regulations than the federal.

Under FIFRA, registrations and product labeling may restrict uses of pesticides. Each registration specifies the crops/sites on which it may be applied, target pests, which the product is meant to control, and each use must be supported by research data (although such data are not required for US EPA registration). As a part of the pesticide registration, US EPA must classify the product or some uses of the product as “general use” where certification or training is not needed, and as “restricted use” where training and certification is needed, because these pesticides cause unreasonable adverse health and environmental effects when they are used inconsistent with the labeling.

Restricted use pesticides are limited to use by pesticide applicators, who are certified by an accredited body (in the US, this is the state’s Department of Agriculture), or to people under the supervision of a certified applicator. Under FIFRA, US states and tribes that choose to certify pesticide applicators submit a state/tribal plan to the US EPA Administrator. The Administrator approves the plan if it meets a number of conditions contained in [FIFRA Section 11\(a\)\(2\)](#), and the power to administer the certification is relegated to the state’s Department of Agriculture.

Certification and training regulations require pesticide applicators to meet certain training requirements before they apply pesticides labeled “for restricted use.” The purpose is to ensure that US federal regulations are being used when using pesticides at the US state level.

Certification Standards

Certification means a person has met the certification standards established by the Pesticide Control Board or other authorizing body of the applicable US state (or if the certification is not administered by the US state, the US EPA retains authority). Certification standards are in the form of a written examination. A person seeking certification has to pass a written test administered by the state’s Department of Agriculture. The test is offered in a “category of interest” (there are many categories of certified applicators). After passing the written test, the applicator can renew the license every year to every three years, as mandated by state regulations. License renewal is obtained by attending a Pesticide Applicator Training Program held jointly by a state university in cooperation with a state’s Department of Agriculture.

Pesticide applicators can also earn continuing education credits (CUEs) on pesticide application by attending several private and public training sessions that are pre-approved by states prior to the training

ANNEX I.

TRADITIONAL METHODS OF PROTECTION AGAINST PESTS OF STORED FOOD

UNDER

THE USAID PROGRAMMATIC ENVIRONMENTAL ASSESSMENT (PEA) FOR
TITLE II FOOD AID COMMODITY PROTECTION AND FUMIGATION

Prepared for:
The PEA Team

Prepared by:
Maureen Babu (Participatory Stakeholder Analyst and NGO Liaison)

March, 2012

INTRODUCTION

In Africa, the bulk of grain is produced by small scale farmers (Blum and Bekele, 2000). Nukenine (2010) further explains that agriculture in Africa is largely traditional and grains constitute the bulk of food production. Sorghum, maize, rice, wheat and millet for cereals and cowpeas, dry beans, groundnut, chickpea and bambara groundnut for pulses, are most common. In India, out of the total grain production, approximately 70% remain in the villages and is stored in traditional structures, the remaining 30% which is surplus destined for the market, is handled by traders and governments (UNESCO).

Agricultural production in these areas is seasonal while the demands for agricultural commodities are more evenly spread throughout the year. Therefore, grain storage becomes a particularly important agricultural activity. Grain storage is done on-farm, peasant farmers' residences (family granaries), community stores and large warehouses. Since most of the grains produced are destined for human consumption, storage in family granaries predominates.

Food security for these farmers, and especially in famine prone countries, depends on their success to grow and store their staple food that they need for their families. This is done while ensuring a minimum loss of quantity and quality, with the use of an effective and affordable storage method. They must be able to keep the stored produce until the next successful harvest, and this might be more than a year, in the case of crop failure. Even in developing countries which have central storage facilities, farmers in peripheral regions find it difficult to procure the needed grains in times of famine, unless they can rely on their own food stores. Purposes for on-farm storage can be summarized as follows: for household food consumption; future cash reserves especially if better prices are expected in the long run; use as seeds in the next planting season; coping strategy in the event of drought; collateral against bank loans.

TRADITIONAL POST HARVEST MANAGEMENT

The time of harvesting varies slightly throughout the agro-climatological zones. Farmers may tend to wait until later in the year for harvesting, more specifically, when the moisture content of the grain is thought to be lower. This factor is considered as the most crucial when deciding on the optimal time for harvesting, especially when the grain will be stored (Nukenine, 2010). Farmers decide when to harvest by experience, examples include: how hard the seeds feel when placed between their teeth and cracked, based on the seed color and according to the coloring of the stem just below the grain head (Blum and Bekele, 2000).

The harvested products are dried even further after threshing and shelling to separate the grains from the cob, pod or ear; winnowing the grain to separate good from damaged grain and debris; and before the eventual storage. Seed drying is mostly done by exposure to the sun rays for a certain period of time and the duration for exposure is dependent on the type of grain. For example, grains that are considered to have high moisture content are exposed to the sun drying method for a longer period. Sun drying is carried out while ensuring that abrupt or over drying of the grains does not occur, as these will reduce the nutrient content or germination capacity of the grains. However, if weather conditions are too cloudy, humid or even wet, then the crop may not be sufficiently dried and post harvest losses could be high.

TRADITIONAL GRAIN STORAGE METHODS

While preparing grain for storage there are three important practices that should be followed: keeping the produce dry, cool and insect free. In tropical climates, the ability to store seeds for an extended period is often limited due to adverse climatic conditions such as heat and humidity. In general, factors influencing grain storage are both scientific and socio-economic in nature. The scientific factors include physical, biological, zoological, chemical and engineering factors, whereas the socio-economic factors are finance, marketing, methods of farming and technical know-how (UNESCO). Examples of scientific factors include pests, rodents, birds and micro-organisms. Their activities result in not only a considerable loss in quantity but also result in qualitative deterioration.

Deterioration of stored grains is described as resulting from the interactions among defective or unfavorable physical, chemical and biological variables that exist in the system. For grain storage facilities including traditional systems, to be considered effective and efficient, the following functional and structural requirements must be met: adequate capacity and strength; ability to withstand all weather conditions; protection from rodents; insulation efficiency; loading and unloading arrangements; economics of the structure.

The length of storage depends on the agro-ecological zone, ethnic group, the quantity of commodity stored, the storage condition, the crop variety stored, etc. Grain is kept longer in the higher altitudes such as in temperate regions where the cooling effect is unfavorable to pest development. Across Africa, grain storage periods generally range between 3 to 12 months. Storage period amongst small and marginal farmers in India vary from 6 to 12 months.

The use of traditional stored product protection methods is very popular among small-scale farmers. The methods are numerous, diverse and widespread across the continents, with regional and country particularities. Those with the ability to store grains without compromising the quality of the stored commodity, protect grain from pest infestation and attack by moulds, thus ensuring that application of fumigants such as aluminium phosphide is rarely or hardly required, shall be explored in the subsequent sections.

Hermetic storage: Hermetic storage (gas tight) is an ancient way of storing grains in clay pots, underground pits or mud-plastered structures. Grain stored under hermetic conditions creates an atmosphere high in carbon dioxide and low in oxygen, thus protecting the stored seeds from insect infestation as these conditions are not conducive for insect production and survival. The low and controlled internal humidity levels in this storage system further provides an environment not conducive for pest infestation or mould growth. Insects' presence has direct influence on grains by creating hot-spots within the stored commodity, in addition to direct destruction of grains through feeding and reproduction (Nukenine, 2010). Hot-spots are areas that experience an increase in grain temperature and moisture contents, which lead to an increase in respiration and consequently loss in quantity and quality of the grain.

This ancient storage principle has been further elaborated and developed into modern storage bags, which have a much better ability to retain the gases produced by the grains and prevent changes in humidity. This is further strengthened by the ability of the hermetic

storage facility to create a gas barrier thus disabling entry of oxygen or humidity from the external environment of the storage facility (Bruin; Feed Technology Update, 2006).

- a) Underground granaries/ pits:** These are commonly found in areas where the water table is low (FAO, 1997; Nukene, 2010). The underground pit may be round or square in shape. Grain stored in pits is especially prone to attack by fungus. Therefore, to isolate the grain from the surrounding soil, lining of the pit becomes an important issue. Different materials can be used for lining such as straw, grass, plastic, dung and cement. Many farmers use more than one material to line the underground pits. In India, the underground pits, referred to as *gudana* have their walls and the floor plastered with cow dung and the floor covered with a fine layer of sand (UNESCO). From experimental research findings, Blum and Bekele (2000) further indicates that grains in pits with plastic lining remain cooler and drier, and lost less dry weight and seed germination rate, compared to grain in pits with grass or cement lining, or none at all. However, the price of plastic is still prohibitive for most small farmers in developing countries.

Usually, after loading the grains into the pit, the mouth of the pit is covered. For example in some regions in Nigeria, a stone slab is used and tree stems placed on top, across the pit, which is then covered with polyethylene or metal sheet etc (Adejumo and Ruji, 2007). The surrounding areas of underground pits are kept free from grass to discourage possible habitation by rodents and hibernation by weevils. Cats are also kept by farmers to keep off rodents.

Overall, it is believed that grains stored in these plastered underground structures are protected against insect attack because of reduced internal oxygen level. Incidences of theft, especially during a scarcity season are believed to be reduced when these underground structures are used.

- b) Earthen pots:** Pots are made of burnt clay. The shape and sizes differ with the locality. Grains stored in earthen pots are known to retain their viability. Also these structures are considered not to be susceptible to attacks by rodents.
- c) Off-the-ground mud/dung plastered structures:** Cow dung or mud coated on the floor and the sides of traditional storage structures prevent entry of insects into the stored grains, including providing airtight conditions within the storage structure.

In Ethiopia, there is the *gotera*, which is a large basket woven from wood, mud and cow dung, with a lid made from the same materials. *Goter*as are located in a cool place that is protected from direct sunshine. The surrounding area is kept free from grass to discourage possible habitation by rodents and hibernation by weevils. Cats are also kept by farmers to keep off rodents. Farmers can store wheat for one year up to five years or more in a *gotera*. Occasionally, farmers store sorghum mixed with *tef*, which is a very small grain and helps to make the content of the *Gotera* airtight and to keep it cool. It also obstructs the movements of insects.

In India, paddy is packed tightly in hay to keep it airtight during storage in cow dung wall plastered structures referred to as *ganaja*. These are temporary structures that are constructed after every harvest. The problem of contamination or infestation of

fresh stocks from instances where a permanent storage facility is not thoroughly cleaned is believed not to occur in the case of *ganaja*, as they are constructed afresh after each harvest.

To protect stored grains against pests such as termites, water or smoke is let into the holes, in the termite hills. Termites are also known to attack timber, and this may include the timber support frame of many traditional storage structures. A project conducted in Zimbabwe in 1996 to 1999, has successfully addressed this problem by modifying traditional storage structures by using PVC pipes filled with concrete as the support frame, totally excluding rodents and termites (Research into Use, 2012).

Botanical pest control agents: The high costs and the erratic supply of chemical pesticides in developing countries have stimulated a renewed interest in traditional botanical pest control agents used in the above traditional grain storage structures. The use of plants and also their local names changes from place to place. Chili pepper and Finger Euphorbia are among the most commonly used biological pest control agents in most countries in Africa.

When grain is stored for seeds like in some parts of Tanzania, farmers sometimes sprinkle urine from a cow or goat or salt over the grain, for preservation. This is done two days before putting the grain into storage to ensure that it is dry. When salt is only used, the grain can be stored directly after dressing. Farmers in Uganda use banana juice, pepper, Mexican marigold and eucalyptus leaves, for pest control in stored grains (FAO, 1997; Nukenine, 2010). In India, neem leaves are mixed along with ragi, a staple food crop for Hunsur region to, keep it free of pests. Additionally, when rice is stored "Umi or Husk" is mixed with it in order to keep it free from pests (UNESCO).

Practically when botanical pesticides are used, farmers place leaves of the local plants, which are assumed to have repellent and protective effects against insects, between grain layers and on top of the stock within the storage system. Additionally, seeds from the fruits of these botanical pest control plants are ground, mixed with water and the mixture applied to the stored grain (Blum and Bekele, 2000).

CONCLUSION

Traditional storage structures are numerous and diverse, but only those with some hermetic characteristics were considered in this review. Though possessing some hermetic abilities, these traditional storage structures may still be prone to biotic and/or abiotic factors. For example, underground granaries may be susceptible during floods. Off-the-ground cow dung or mud plastered structures may eventually develop cracks which could be entry points for pests, rodents and external air & humidity. Additionally, the storage system frame, if made of wood, may be susceptible to termite attacks and favor other sources of infestation. There is also the concern that the actual effect of traditional botanical pesticides is yet to be experimentally demonstrated, though there are indigenous reports of success.

Interestingly, the hermetic characteristics have been improved and scaled upwards into modern storage facilities such as Cocoons, which allows for bulk storage like in the case of food aid. These have been used in Rwanda, Philippines and Thailand to mention but a few. Cocoons are described as hermitically sealed "silos." Herein, bagged grains are stored under

modified atmospheric conditions, insulated from ambient atmosphere by means of a special fabric that serves as a gas barrier. The metabolism of any organisms or insects that may have made its way into the stored products creates a modified atmosphere that is low in oxygen and high in carbon dioxide. The low permeability, flexible PVC material used in the Cocoons both prevent changes in humidity and protects the stored grains from rodents. The modified atmosphere controls the proliferation of pests, prevents growth of fungi and slows down oxidation. Bruin and Feed Technology Update (2006) further state that with the use of Cocoons, all the quality aspects of the stored grains are protected without the need of aeration or fumigation. Whereas in non hermetic conditions, stored grains are exposed to atmospheric oxygen and external humidity, and therefore insect infestation cannot be controlled without the use of toxic pesticides.

REFERENCES

Blum, A. A., and Bekele, A. 2000. The use of indigenous knowledge by farmers in Ethiopia when storing grains on their farms- A paper submitted to the 16th Symposium of the International Farming Systems Association.

Bruin, T. Innovations in Seed Storage Methods, Grain Pro Inc., The Phillipines

FAO. (2012)- Corporate Document Repository 1997. *Agriculture, food and nutrition for Africa: a resource book for teachers of Agriculture*. Retrieved March 6, 2012, from <http://www.fao.org/docrep/w0078e/w0078e07.htm#TopOfPage>

Feed Technology Update.2006.Solutions for the Global Feed Industry.Linx Publishing, LLC., USA

Nukenine, E.N. 2010. Stored Product Protection in Africa: Past, present and future in 10th International Working Conference on Stored Product Protection. Julius-Kühn-Archiv.2010. pp 425

Research into Use. (2012). *New designs for storage structures give farmers important options- better grain stores for farmers and traders*. Retrieved March 6, 2012, from <http://www.researchintouse.com/nrk/RIUinfo/PF/CPH23.htm#L1>

UNESCO, Integrating Women in Development Planning - The Role of Traditional Wisdom. M.A. Singamma Sreenivasan Foundation, Bangalore, India.

ANNEX J PICTURES OF FOOD AID COMMODITY STORED IN WAREHOUSES IN UGANDA, ETHIOPIA, AND DJIBOUTI

(All pictures were taken during the PEA Team's fieldwork, and were taken by PEA Team members.)



Photo no. 1: ACDI/VOCA Warehouses with Cats. (Animals should be prevented from entering the warehouse)



Photo no. 4: Polypropylene Bag with Wheat Showing Gaps Near the Stitches. (Insects can easily enter through these openings (Adama, Ethiopia)



Photo no. 2: ACDI/VOCA Warehouse with Open Doors (This will let birds, rodents, and insects easily gain access into the warehouse)



Photo no. 5: Gaps near Seams Large Enough for Insect Entry (Adama, Ethiopia)



Photo no. 3: Save the Children Warehouse in Adama, Ethiopia showing gaps underneath the door



Photo no. 6: Poorly Lit Warehouse Interior (WFP, Adama, Ethiopia). A Handheld Machine for Stitching Torn Bags



Photo no. 7: Spillage of Wheat on Rubber Pallets (WFP, Adama, Ethiopia)



Photo no. 10: Torn Corn Soy Blend Being Rebagged (Catholic Relief Services, Adama, Ethiopia)



Photo no. 8: Bird Fecal Material on Corn Soy Blend (Catholic Relief Services Warehouse, Adama, Ethiopia)



Photo no. 11: Pesticide (includes AIP) Storage Shed with permanently open meshed windows (WFP, Adama, Ethiopia)



Photo no. 9: Tents Used for Food Aid Commodity Storage (Catholic Relief Services, Adama, Ethiopia)



Photo no. 12: Dust Masks Used During Phosphine Fumigation (WFP, Adama, Ethiopia)



Photo no. 13: Sand Snakes Used to Hold Down Fumigation Sheets (WFP, Adama, Ethiopia)



Photo no. 16: Bulk Wheat Being Bagged and Stitched at Djibouti Port



Photo no. 14: Fumigation Sheets in Storage (WFP, Adama, Ethiopia)



Photo no. 17: Bagged Wheat in Temporary Storage at Djibouti Port



Photo no. 15: Grain Being Pneumatically Unloaded From a Ship Hold. Note Birds (circled in red) Inside The Hold (Djibouti Port)



Photo no. 18: Spillage underneath Pallets at a Warehouse in the Free Zone (Djibouti)



Photo no. 19: Corn Soy Blend Spillage with Insect Trails in a Djibouti Warehouse in the Free Zone



Photo no. 21: Nail Sticking Out of a Pallet. Note Spillage of Corn Soy Blend (Warehouse in Free Zone, Djibouti)



Photo no. 20: Birds Roosting on a Light Fixture Warehouse in the Free Zone in Djibouti



Photo no. 22: Pit Used to Dispose Empty Phosphine Containers (WPF, Adama, Ethiopia)

Insert USAID Food Assistance Program Name

Phosphine Fumigation Management Plan (Sheeted Stacks Only)

Planned fumigation dates:	[insert dates]
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ATTENTION:
This plan must be completed for
every fumigation event.

Each completed plan must be
retained on-site for 2 years.

A. OVERALL PROGRAM & CONTACT INFORMATION	
Lead Awardee	
Program Name	
Fumigation Compliance Lead	
Compliance Lead Contact Information	

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. CONTACT INFORMATION: MEDICAL FACILITY; EMERGENCY RESPONSE AUTHORITIES		
	Location	Telephone
Police (if available)		
Fire Service (if available)		
Clinic/Hospital		
Other Local Authority (specify Port Authority, District Council, Chieftancy, etc.)		
Pesticide Regulatory Authority		
Chief of Party		

E1. 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.

E2. ADVANCE NOTIFICATION PLAN FOR LOCAL AUTHORITIES
Specify the procedure for notifying local authorities, as required or agreed with these authorities.

F. EMERGENCY RESPONSE PLAN
F1. 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).

G. COMMODITY TO BE FUMIGATED	
Commodity(ies) & Amount in tons (est)	e.g. maize 200mt.
How packaged	
# of stacks & size	e.g. 4 stacks 3m X 2m X 2m
Last fumigation	Enter date if known. Otherwise, enter "unknown"
Condition	Moldy? Vistibly infested?
Moisture %	
Purpose of Fumigation	

H. FUMIGANT PRODUCT INFO & DOSAGE	
H1. Fumigant	(product name/description)
H2. Ambient Temp	Expected indoor temp range
H3. Quantity Req'd*	
H4. Required time @ concentration*	e.g. 7 days @ 200ppm
H5. Planned downtime*	Days + hours, includes aeration.
REQUIRED: DOCUMENT CALCULATIONS H3, H4 & H5 IN ANNEX #A. NOTE THAT EFFECTIVE PHOSPHINE FUMIGATION TYPICALLY REQUIRES 7-10 DAYS. .	

I. MAKE SPATIAL FUMIGATION PLAN & DETERMINE EXCLUSION ZONE			
Required Action	Y	N	Confirming initials
I1. Obtain plot or make scale sketch map of facility and surroundings (note grid paper is provided as final page of this template)			
I2. Mark locations of stacks to be fumigated.			
I3. 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.			
I4. Determine if a watchman or watchmen will be required to maintain the exclusion zone. If yes, inform the facility manager immediately.			
I5. On plot, mark shut-off points for electricity, water, gas, if any			
I6. On plot mark doors/gates to be secured to enforce exclusion zone and locations of warning signs to be posted			
I7. On plot, mark locations of hazard monitoring (at least 3 locations just outside exclusion zone, where gas is mostly likely to accumulate)			
I8. On plot, mark locations of phosphine trays and monitoring lines.			
I9. Attach plot to this Fumigation Management Plan as Annex #F			

J. DETERMINE SUITABILITY OF FACILITY, STACKS AND TEAM FOR FUMIGATION			
Fumigation may NOT proceed unless ALL criteria are met.			
Mandatory Decision Criteria. Confirm that:	Criterion is. . .		Confirming Initials
	Met	Not Met	
J1. Commodities being fumigated are not required before the end of the planned down time (H5) + 1 day.			
J2. Expected temperature during the fumigation period will be 15°C or above			
J3. Stacks are NOT built around pillars or against walls, and that there is sufficient clearance (1m) around each stack to effectively sheet and seal.			
J4. 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.			
J5. The marked exclusion zone (see I3) can be maintained for the <u>duration of the fumigation</u> (7-10 days or more). (Exclusion = no people EXCEPT for fumigation personnel with proper breathing equipment in this zone.)			
J6. A <u>trained</u> 2-person (or larger) team is available for application of fumigant and aeration and the team holds any required host country licenses.			
J7. If watchmen are required to maintain the exclusion zone, they will be available over			

the entirety of the fumigation period, including aeration time.			
J8. The warehouse is completely empty (including non-food commodities) during the fumigation			

K. DETERMINE 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>1m</u> overlap, tightly rolled & then clipped or weighted. If clips are used, they must be applied every 20cm.)	Indicate number & size of sheets, standard 18 X12m sheets preferred
K2. Determine length of sand snakes required (double rows must be used)	(in meters)
K3. Determine number of phosphine tablet trays required	

L. CONFIRM 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) Dry, clean cotton gloves 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 (H3) 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 tears mended with material-specific adhesive and patch. Light enough to carry (200-250g/m²) a full standard-size (18mX12m) sheet <p>250-micron (0.25mm) thickness PVC sheet,</p>	<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 PEA Annex T-9.<u>NOTE. Canister/cartridge type respirators are NOT adequate to enter a fumigation enclosure (e.g. go into a sheeted container)</u></p>
	M3. Monitoring Equipment

PVC on a nylon or terylene scrim, or multi-layer thin-film laminates are all acceptable.	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.
Thin coatings on widely woven materials and annealed polypropylene sheets NOT acceptable	See PEA Annex T-9 for more information

N. LOG RESPIRATORY AND DETECTION EQUIPMENT			
Required Action: Complete log of all Respiratory and Detection Equipment.			
Description	Manuf & Model #	Manuf Date (if known)	Serial Number
e.g Canister Respirator			

O. BRIEF FUMIGATION TEAM & FACILITY MANAGER			
Required Actions	Y	N	Confirming initials
O1. Fumigation team reviews product label, MSDS, and applicator/product manual. Lead applicator provides detailed verbal briefing if required.			
O2. Lead applicator briefs the team regarding the symptoms of phosphine poisoning and first aid. (See Fumigation PEA Annex T-10)			
O3. Lead applicator briefs the team regarding the planned fumigation process with reference to the site plot (I10) WITH FACILITY MANAGER PRESENT			
O4. Lead applicator briefs the team & facility manager on EMERGENCY RESPONSE PLAN (F1) & roles and responsibilities for implementing the plan are agreed.			
O5. All employees engaged in fumigation instructed on the use, impact, and mitigation measures of phosphine fumigation.			

P. NOTIFY AND POST WARNING SIGNAGE, ASSURE WATCHMEN ON STANDBY			
Required Actions	Y	N	Confirming initials
P1. Notify Abutters per Notification Plan (E1). In particular, ensure that nearby residents have been informed of activity,			
P2. Notify Workers and any others with customary access to the exclusion zone. Brief on emergency response plan (F1)			
P3. If applicable, execute Local Authorities Notification Plan (E2)*			
P4. Post warning signage 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.			

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

Q. SHEET THE 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 meter of sheet lying on the ground. Unroll the sheet to cover the entire stack. If more than one sheet is used, join the sheet. Joins require a 1m 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. 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 <u>NOT</u> 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 IF SCBA apparatus are used. 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
T1. Efficacy Monitoring results show that the required phosphine gas concentration was sustained over the required period in each stack		e.g. 200 ppm @ 7 days
T2. Efficacy monitoring results show that the required concentration was NOT sustained over the required period in one or more stacks.		(Copy from H4)

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.			

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 an 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)ays and hours
#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.

[illegible]

*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)

A full-page sheet of white graph paper featuring a uniform grid of thin black lines. The grid consists of small squares covering the entire area, typical of standard graph paper used for mathematics or design.

[illegible]

*This is a **Food Commodity Protection PERSUAP template** for use by Title II partners. **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**

Office: Office of Food for Peace (FFP)
Title of Program: insert Title II program name
Awardee: insert organization name
Host Country/Region: insert implementation country and region e.g. Ethiopia/Africa

Note: SUAP requirements (see section 7 of main document) will be incorporated as needed into program Detailed Implementation Plan (DIP) and Budget

Funding Begin: insert date Funding End: insert date Funding End: insert date
Prepared by: insert name, organization, contact info Submission Date: insert date

IEE Amendment (Y/N): YES If "YES": Date of Original IEE: insert IEE clearance date
Env Compl Database link: insert link to IEE on
<http://gemini.info.usaid.gov/egat/envcomp/>

ENVIRONMENTAL ACTIONS RECOMMENDED: (Place X where applicable)

☐ **Request for Categorical Exclusion(s):** activities have no adverse effect (i.e., training, technical assistance; not to include any infrastructure rehabilitation.)

☒ **Negative Determination:** no significant adverse effects expected for activities which are well defined over life of the award

☐ **without conditions** (no special mitigation measures needed)

☒ **with conditions** (mitigation measures specified)

☐ **Positive Determination:** potential for significant adverse effect of one or more activities. Appropriate environmental review needed/conducted.

☐ **Deferral:** elements not well defined; activities will not be implemented until amended IEE is approved. Briefly describe here

ENVIRONMENTAL MEDIA AND/OR HUMAN HEALTH POTENTIALLY IMPACTED (Check all that apply)

☒ Air | ☐ Water | ☐ Land | ☐ Biodiversity (deforestation) | ☒ Human Health | ☒ Social | ☐ None

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 section 7 of the PERSUAP. The SUAP imposes the mitigation requirements (safer use conditions) established by the Programmatic Environmental Assessment

“Commodity Protection in Title II Food Aid Programs by Phosphine Fumigation.”

APPROVAL OF RECOMMENDED ENVIRONMENTAL ACTION

A. Food for Peace Mission or Regional Office, as appropriate:

_____	Date _____
Mission Environmental Officer	
_____	Date _____
Regional Environmental Advisor*	
_____	Date _____
Regional/Mission Food for Peace Officer*	
_____	Date _____
Mission Director	

B. Food for Peace, Washington

_____	Date _____
Agreement Officer's Representative	
_____	Date _____
Agreement Officer	

C. Concurrence:

_____	Date _____
Erika Clesceri, DCHA Bureau Environmental Officer	

Accepted: ☐

Not Accepted: ☐

*Clearance is suggested but not mandatory

USAID INITIAL ENVIRONMENTAL EXAMINATION- AMENDMENT

Pesticide Evaluation Plan and Safer Use Action Plan (PERSUAP) for Commodity Protection by Phosphine Fumigation & Contact Pesticides

USAID Food Assistance Program Data

Program Name:

Awardee:

Country/Region:

Period of Performance: years (start date – end date)

1. Purpose and Scope of PERSUAP

Upon approval, this Food Commodity Protection PERSUAP, submitted as an amendment to the IEE, will authorize phosphine fumigation of food commodities. It will also authorize complementary use of the contact pesticide(s) 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 , subject to the **condition** that the Safer Use Action Plan provided as Section 6 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 “Commodity Protection Title II Food Assistance Programs by Phosphine Fumigation” (Henceforth the “Fumigation PEA.”)¹

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, secondary, tertiary 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, particularly in Title II implementation circumstances. 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.

¹ *Approved (insert date). Insert USAID Environmental Compliance Database link, when uploaded.*

4. Proposed pesticide(s).

This PERSUAP requests approval to use aluminum phosphide 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
(a) USEPA registration status of the proposed pesticide. Host country registration status	<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. <i>Aluminum phosphide</i> 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>. <i>Aluminum phosphide</i> is widely used for fumigation of food commodities and structures.</p> <p>Provide analogous host country registration information and any restrictions established by this registration</p>
(b) Basis for selection of the pesticide	<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>
(c) Extent to which the proposed pesticide use is, or could be, part of an IPM program	<p>The Safer Use Action Plan requires compliance with Fumigation PEA Annex T-6 "IPM PRACTICES & INSPECTION CHECKLIST FOR TITLE II COMMODITIES AND WAREHOUSES." This is a version of the checklist contained in the Food for Peace Commodity Reference Guide modified to implement key 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</p>

	<p>commodities in the warehouse.</p> <p>(list any additional IPM food commodity protection practices to which the program is committing.)</p>
(d) Proposed method or methods of application, including the availability of application and safety equipment	<p>Aluminum phosphide will be used for indoor fumigation of warehoused food commodities in sheeted stacks only. Via the Fumigation Management Plan, the SUAP requires that fumigation follow acceptable technical practices specified in Annex T-7 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>Note if the program's fumigation services provider will provide PPE and monitoring equipment, or if the program will do so.</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>The potential toxicological effects of <i>aluminum phosphide</i> are well covered by EXTOWNET, 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 <i>aluminum phosphide</i> 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 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>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 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>
(f) Effectiveness of the requested pesticide for the proposed use.	<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>
(g) Compatibility of the proposed pesticide use with target and non-target ecosystems.	<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>
(h) The conditions under which the pesticide is to be used, including climate, flora, fauna, geography, hydrology, and soils	<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 range between X°C & Y°C and humidity between X and Y%..</p>
(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. 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 in and around warehouses is usually an integral part of the fumigation process to</p>

(j) The requesting country's ability to regulate or control the distribution, storage, use and disposal of the requested pesticide	Host country registration status is documented under Factor A, above. Note whether phosphine fumigation requires a license in your host country, and the requirements for obtaining such a license. Note whether such licensing is meaningfully enforced.
(k) The provisions made for training of users and applicators	Regardless of host country licensing, describe the training standard of fumigator service provider personnel. t
(l) The provisions made for monitoring the use and effectiveness of the pesticide	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.

Factor Analysis for [insert name of contact pesticide]

Analysis factor	Analysis
(a) USEPA registration status of the proposed pesticide. Host country registration status	Provide EPA registration status. Note that the pesticide must be registered for the same or similar uses by US EPA. Provide analogous host country registration information and any restrictions established by this registration. Note that the pesticide must be registered in the host country AND by US EPA.
(b) Basis for selection of the pesticide	Availability, cost, efficacy, and relatively low toxicity to humans and non-target organisms should be key selection factors/
(c) Extent to which the proposed pesticide use is, or could be, part of an IPM program	The Safer Use Action Plan requires compliance with Fumigation PEA Annex T-6 "IPM PRACTICES & INSPECTION CHECKLIST FOR TITLE II COMMODITIES AND WAREHOUSES." This is a version of the checklist contained in the Food for Peace Commodity Reference Guide modified to implement key 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. (list any additional IPM food commodity protection practices to which the program is committing.)
(d) Proposed method or methods of application, including the availability of application and safety	

equipment	
(e) Any acute and long-term toxicological hazards, either human or environmental, associated with the proposed use, and measures available to minimize such hazards.	
(f) Effectiveness of the requested pesticide for the proposed use.	Describe any resistance reported or known to you.
(g) Compatibility of the proposed pesticide use with target and non-target ecosystems.	
(h) The conditions under which the pesticide is to be used, including climate, flora, fauna, geography, hydrology, and soils	<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>
(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. 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 in and around warehouses is usually an integral part of the fumigation process to</p>
(j) The requesting country's ability to regulate or control the distribution, storage, use and disposal of the requested pesticide	<p>Host country registration status is documented under Factor A, above.</p> <p>XXX does/does not have t</p>
(k) The provisions made for training of users and applicators	
(l) The provisions	The SUAP requires, via the

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**
- **Implementation of a Fumigation Management Plan** for each fumigation event substantively conforming to the plan provided as Annex T-3 to the Fumigation PEA, EXCEPT as noted in the SUAP.
- **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, EXCEPT as noted in the SUAP.
- **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, EXCEPT for changes specified below and/or subsequently approved by the DCHA 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.

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 as an annex to the Environmental Status Report.

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

[Insert USAID Food Assistance Program Name]

Fumigation Safer Use Action Plan & Compliance Tracker

This is an integral part of the PERSUAP and must be submitted annually with Environmental Status Report (ESR).

PROGRAM & CONTACT INFORMATION		DATE OF ANNUAL REPORTING SUBMISSION:	
Awardee		Annual Update #1	
Program Name		Annual Update #2	
Fumigation Compliance Lead	Name and title	Annual Update #3	
Contact Information	Email & telephone	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	ACTIONS PLANNED TO ACHIEVE & MAINTAIN COMPLIANCE (w/ deadlines & responsible party)	STATUS OF COMPLIANCE ACTIONS (for instance text)
<p>Good Housekeeping IPM Measures. Fully implement the daily/weekly warehouse and commodities inspection checklist (Fumigation PEA Annex T-5) and take maintenance/corrective actions specified.</p> <p><i>NOTE: compliance with this checklist implements a set of IPM measures that are essential complements to fumigation.</i></p>		
	(insert extra rows if needed)	
<p>Fumigation Management Plan. A fumigation management plan (FMP) will be implemented for each fumigation event. The FMP and the actual fumigation process will substantively conform to the plan provided as Annex T-3 to the Fumigation PEA, EXCEPT for changes specified below and/ or subsequently approved by the DCHA BEO. Each completed plan shall be retained for 2 years.</p>		
	(insert extra rows if needed)	
<p>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, EXCEPT for changes specified below and/or subsequently approved by the DCHA BEO.</p>		
	(insert extra rows if needed)	
<p>Storage and Transport of Aluminum Phosphide and Contact Pesticides, if under program control, substantively conform to contact pesticide best practices as set out in Fumigation PEA Annex T-6, EXCEPT for changes specified below and/or</p>		

subsequently approved by the DCHA BEO.	(insert extra rows if needed)	
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.		
	(insert extra rows if needed)	
Monitoring and Corrective Action. Program will actively monitor compliance with above-listed conditions and undertake corrective actions as needed.		
	(insert extra rows if needed)	

REQUESTED EXCEPTIONS AND CHANGES TO SPECIFIED MANAGEMENT PRACTICES Enter here specific requested exceptions or changes to fumigation practices as per template Fumigation Management Plan provided by the Fumigation PEA Annex T-3 or storage, transport, and contact pesticide practices per Annex T-6. Reference by number & provide justification in each case. Alternately, a strike-through edit of the FMP may be submitted.
(add lines as necessary. . .)