U.S. Department of Agriculture
Grain Inspection, Packers and Stockyards
Administration
Federal Grain Inspection Service
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CHAPTER 1

GENERAL INFORMATION

1.1 PURPOSE

This handbook contains the Grain Inspection, Packers and Stockyard Administration (GIPSA), Federal Grain Inspection Service (FGIS) policies and procedures for the fumigation of grain and certain other commodities. To successfully interpret and apply these policies and procedures, it is essential that FGIS and agency personnel become familiar with basic information regarding fumigants and fumigation.

1.2 DEFINITIONS

The following definitions relate to terms used in this Handbook or terms likely to be used by persons in or associated with the fumigation industry.

Aerosol - A suspension of liquid or solid particles of a chemical in the air. Unlike gases, these particles penetrate commodities. Aerosols are often referred to as smokes, mists, or fogs.

Aluminum Hydroxide - Residue remaining after the decomposition of the fumigant aluminum phosphide. Small amounts of unreacted aluminum phosphide may also remain in the gray-white aluminum hydroxide dust. Aluminum hydroxide is a clay-like compound that is nonpoisonous.

Aluminum Phosphide - A chemical that reacts with moisture to release the fumigant, phosphine, or hydrogen phosphide. The aluminum phosphide fumigant formulation contains approximately 55 percent aluminum phosphide and 45 percent inert ingredients to regulate the release of the fumigant and suppress flammability. Inert ingredients may include ammonium carbamate, ammonium bicarbonate, urea, and paraffin.

Application Method - The process used to administer a fumigant formulation.

Certified Applicator - Any individual who is certified to use or supervise the use of any restricted use pesticide covered by their certification. This definition is contained in the Code of Federal Regulations (CFR)(40 CFR 171.2(h)) promulgated by the U.S. Environmental Protection Agency (EPA).

Concentration - The actual amount of fumigant present in the airspace in any given part of the structure being fumigated at any given time.

Dosage - The amount of fumigant formulation applied, often expressed as the weight of the fumigant per volume of space treated or the weight of chemical per weight of commodity.

Efficacy - The power to produce a desired effect; i.e., a satisfactory kill of infestation in the egg, pupae, larval, or adult stage.

Fumigant - A chemical which, at the required temperature and pressure, exists in the gaseous state in sufficient concentrations to be lethal to a targeted pest.

Fumigant Formulation - The chemical or mixture of chemicals comprised of all active and inert (if any) ingredients which releases a fumigant. Fumigant formulations may exist in any of the three physical states: liquid, gas, or solid.

Fumigation - The action of releasing a toxic chemical in the gaseous state to control a targeted pest.

Gas - The state of matter distinguished from the solid and liquid states by very low density and viscosity, relatively great expansion and contraction with changes in pressure or temperature, the ability to diffuse readily, and the spontaneous tendency to become distributed uniformly throughout any container.

Gas Permeable Separation – One that is porous enough to allow air and water vapor into the fumigate pack and the release fumigate out of the pack but which will keep the residue created in the pack.

Granule - Finely divided chemical formulation as small particles. A granular formulation of aluminum phosphide is packaged in moisture permeable envelopes or sachets.

Hydrogen Phosphide – Another name (state) for phosphine.

In-transit Fumigation (FGIS) – A procedure used to fumigate qualifying shipments whereby the carrier may sail before the results are verified. Based on prior USDA research, efficacy of the treatment is assumed to be accomplished; provided, all the carrier criteria and treatment requirements are met and verified by FGIS personnel.

Magnesium Phosphide - A chemical compound that reacts with moisture to release the fumigant, phosphine, or hydrogen phosphide. These formulations contain magnesium phosphide as the active ingredient.

Metal Phosphide – A generic term when referring to aluminum or magnesium phosphide formulations. Metal phosphides are solids that react with moisture and temperature to liberate hydrogen phosphide. These fumigants can contain either aluminum or magnesium formulations. There are other metal phosphide compounds; however, they are not used for fumigation.

Parts by Volume - The relative number of gas molecules present in a given volume of air, such as parts per million (ppm) or parts per billion (ppb). These values are frequently used in human and mammalian toxicology and in applied industrial hygiene to indicate concentration.

Pellets - Aluminum phosphide formulated as a spherical-shaped mass 3/8 of an inch in diameter, weighing about 0.6 grams that release 0.2 grams of phosphine.

Phosphine (PH3) - A colorless, odorless gas having a low molecular weight, low boiling point, and specific gravity of 1.21 in relation to air. The gas diffuses rapidly and is capable of penetrating deeply into materials, such as bulk grains. Phosphine is flammable at concentrations above 1.79 percent by volume in air.

Recirculation - The act of moving a fumigant (accomplished with fans located inside the fumigated space) throughout a space being fumigated to prevent stratification and provide an even distribution of the fumigant.

Restricted-Use Pesticide - A pesticide that is classified for restricted use under the provisions of Section 3(d)(1)(c) of the Federal Insecticide, Fungicide, and Rodenticide Act, as amended (Pub. L. 92-516, 86 Stat. 973). Statements indicating that a pesticide is classified, as "restricted use" must appear on the EPA approved label. Aluminum phosphide is classified as "restrictive use." Restricted use pesticides can only be used by or under the supervision of a certified applicator.

Residue - The active ingredient(s), metabolite(s), or degradation product(s) that can be detected after the use of a pesticide.

Residual Pesticide - A pesticide that is active only at or near the point of application and persists for extended periods in sufficient concentrations to be lethal to targeted pests. An example of a residual pesticide is Malathion. Residual pesticides are often referred to as contact insecticides.

Sachet - A moisture permeable envelope containing aluminum phosphide in a granular formulation. Each sachet weighs approximately 34 grams and will release about 11 grams of phosphine. The envelopes may also be placed in cloth strips referred to as bag blankets or belts.

Separation – a permeable or impermeable partition(s) between two or more distinct lots of grain within a specific stowage space.

Specific Gravity (gas) - The weight of a gas compared to the weight of an equal volume of air under prescribed conditions of temperature and pressure. The specific gravity of phosphine gas is 1.21 with the value of air being 1.0. Therefore, phosphine is slightly heavier than air.

Static Fumigation - A method of fumigation in which the carrier/cargo must remain stationary for the EPA-specified exposure time period and the treatment efficacy verified before being allowed to move into commercial channels.

Tablet - Aluminum phosphide formulation in a spherical or flat and round shape weighing approximately three grams that release approximately one gram of phosphine.

Tubing - Hollow cylinder constructed of polyethylene or similar material attached to a blower motor by bolt, clamp, screw, or other semi-permanent device, used in conveying gases in the recirculation system of fumigation.

Witness of Fumigation (FGIS) – A service whereby the verification of a fumigant's application to a specified cargo is provided.

1.3 FUMIGANT PROPERTIES

a. General.

Fumigation is defined as the process of releasing and dispersing a toxic chemical that reaches a targeted pest in the gaseous state. An ideal fumigant should have the following characteristics:

(1) Highly toxic to all life stages of the targeted pest.

(2) Low toxicity to plants and humans and other non-target organisms.

(3) Readily available and economical to use.

(4) Imparts no harmful residue to the commodity.

(5) Easily detected warning properties.

(6) Nonflammable, non-corrosive, and non-explosive under normal application conditions.

(7) Non-injurious to product quality, seed germination, or end use quality.

(8) Highly volatile with excellent penetration properties and easy to aerate.

(9) No adverse effect on the environment.

Unfortunately, no single fumigant has been developed that possesses all of these properties.

The efficiency of fumigants is influenced, in part, by the method of application. Fumigants may be applied singly or combined with other chemicals to improve efficacy or minimize potential hazards, such as flammability. For example, aluminum phosphide formulations contain one or more of the following: ammonium carbamate, ammonium bicarbonate, urea, and paraffin. These materials regulate release of phosphine and suppress flammability.

Fumigant formulations can be applied as a gas or solid. The commodity to be treated must be in a sealed enclosure to retain the fumigant for a sufficient length of time to control the target pest. Such sealed enclosures may include the use of wood, plastic, fiberglass, steel, or concrete.

Under the treatment situations covered in this handbook, aluminum phosphide has proved successful in controlling all life stages of insects injurious to stored grain. Substantial research has been conducted to verify the safety and effectiveness of aluminum phosphide under various conditions. Aluminum phosphide has been selected based on its physical, chemical, and biological properties.

Table 1 presents some of the important properties of phosphine.

TABLE 1

Essential Properties of Phosphine

Molecular Weight	34.0
Boiling Point [1/]	- 87.4C (-125.3F)
Specific Gravity [2/] (Air = 1)	1.21
Lower Explosion Limit [3/]	1.79%

Comments: Highly toxic, slightly heavier than air, excellent penetration properties, easy to aerate.

1/ Boiling point at 760 mm pressure.
2/ Values greater than 1.0 are heavier than air.
3/ Percent by volume of gas in air.

b. Aluminum Phosphide.

Aluminum phosphide reacts with moisture in the air to produce phosphine (hydrogen phosphide) which is highly toxic to all forms of animal and human life. Phosphine is a colorless, odorless gas. However, an odor of carbide, decaying fish, or garlic occurs from contaminants as the aluminum phosphide produces phosphine. Aluminum phosphide formulations are composed of approximately 55 percent aluminum phosphide and 45 percent inert ingredients, such as ammonium carbamate, ammonium bicarbonate, urea, and paraffin.

Aluminum phosphide is manufactured in pellet, tablet, and granular formulations. The pellets weigh about 0.6 grams and release 0.2 grams of phosphine, and the tablets weigh approximately three grams and release one gram of phosphine. Pellets or tablets are often placed in moisture permeable enclosures to retain the residual dust. The granules are placed in moisture permeable envelopes, sachets, or bags that may in turn be placed in cloth strips, blankets, or belts.

Each sachet weighs about 34 grams and releases about 11 grams of phosphine. The acceptable formulations and applications of aluminum phosphide listed in this handbook employ's the use of these three basic formulations.

When the aluminum phosphide formulations react with the moisture in the air, ammonia and carbon dioxide are released along with the phosphine. The formulations of aluminum phosphide react slowly to produce phosphine. Reaction of the formulation generally starts about 1-2 hours after exposure to the atmosphere. The rate of reaction varies with moisture and temperature and will take place quicker on days with higher moisture (humidity) and temperature.

When reaction of the aluminum phosphide with moisture is complete, a fine, gray-white powder remains. This powder is composed of nonpoisonous aluminum oxide hydrate and a small amount of unreacted aluminum phosphide. In bulk grain, this small amount of unreacted aluminum phosphide reacts quickly in the handling or unloading process without hazard to workers or leaving objectionable residues on the commodity. Several manufacturers have developed special packaging devices for pellets or tablets to retain the residual dust the same as with granules which are placed in envelopes, sachets, or bags. These packages allow easy removal of all residual dust after aeration of the commodity. These packages or other similar devices (designed to retain residual dust) are used for processed commodities, such as corn meal, flour, and milled rice, in order to meet the EPA requirement that under no condition should any processed commodity come in contact with aluminum phosphide residues.

1.4 SAFETY

The fumigation policies and procedures contained in this handbook are based on extensive research. In conducting the research, a major objective was the evaluation of safety for all parties involved with the fumigation. The results of the research studies have demonstrated the safety of the fumigation procedures contained herein.

In performing their responsibilities under this handbook, official personnel should have no occasion for exposure to dangerous concentrations of fumigants. However, it is prudent that all official personnel be familiar with some basic safety precautions.

a. Restricted Use Pesticide.

Perhaps the first level of safety is the classification of pesticides by EPA. In reviewing aluminum phosphide, EPA classified the fumigant as a restricted use pesticide. This means that only certified applicators can purchase and apply these fumigants.

b. Certified Applicator.

A certified applicator is any individual who is certified by the proper licensing authority to use or supervise the use of any restricted use pesticides covered by their certification. Certification is defined by EPA as the recognition by a certifying agency that a person is competent and thus authorized to use or supervise the use of restricted use pesticides. The certification is conducted by individual states or local agencies under guidelines established by EPA. The certified applicator adds another measure of safety to the fumigation program by supervising individuals using restricted use pesticides.

c. EPA Labeling.

The EPA registers labeling for pesticides. By EPA regulation, each label must contain the following information:

(1) The name, brand, or trademark under which the product is sold.

(2) The name and address of the producer, registrant, or person whom the product was produced.

(3) The net contents (weight or measure) of the product.

(4) The product registration and establishment number.

(5) An ingredient statement listing the name and percentage by weight of each active ingredient and the total percentage by weight of all inert ingredients.

(6) Warning or precautionary statement. The specific text is determined by the toxicity category of the pesticide established by EPA. There are four categories of toxicity. The most toxic category requires the use of the term "Danger," the next lower toxic category requires the term "Warning," and the two least toxic categories require the term "Caution" to appear on the label. In addition, since aluminum phosphide is in the most toxic category, a statement of practical medical treatment must also appear on the label.

(7) Directions for use.

(8) The classification use, general or restricted. Restricted use pesticides, such as aluminum phosphide, have the following statement on the label:

"For retail sale to and use by Certified Applicators only. For use by Certified Applicators or persons under their direct supervision, and only for those uses covered by the Certified Applicator's certification. Refer to the directions to this Applicator's Manual for requirements of the physical presence of a Certified Applicator."

The EPA labeling provides a great deal of useful information. All FGIS and agency personnel involved with the fumigation procedures in this handbook should retain a copy of the label(s) for reference purposes and become familiar with the safety precautions listed on the label.

d. Symptoms of Exposure.

Although there should be no occasion where FGIS or agency personnel encounter hazardous fumigant concentrations in implementing the procedures in this handbook, it is advisable to be fully aware of the symptoms of exposure to phosphine.

SYMPTOMS OF EXPOSURE TO PHOSPHINE ARE:

(1) Slight or mild poisoning which produces a feeling of fatigue, ringing in the ears, nausea, pressure in the chest, and uneasiness. All of these symptoms will normally disappear when the person is removed to fresh air.

(2) Moderate exposure that leads to general fatigue, nausea, gastro-intestinal symptoms accompanied by vomiting, stomach ache, diarrhea, disturbance of equilibrium, strong pains in the chest, and difficulty in breathing.

(3) Exposure to very high concentrations which rapidly produces strong difficulty in breathing, bluish-purple skin color, difficulty in walking or reaching, subnormal blood oxygen content, unconsciousness, and death. Death can be immediate or may be delayed until several days later.

e. Treatment.

As discussed earlier, the EPA approved label contains information regarding practical treatment regimes. If any of the symptoms previously described are experienced, a physician should be contacted immediately. To expedite proper treatment, it is advisable to have a copy of the EPA approved label available for the physician. Generally, the most up-to-date information regarding medical treatment for exposure is available from the fumigant manufacturer. The EPA approved label contains the manufacturer or distributor's name, address, and phone number. FGIS field offices and agencies should maintain a list of emergency phone numbers including those of the nearest hospital.

f. Exposure Limits.

Exposure limits for various pesticides and other substances have been developed by several organizations. Since the exposure limits are continually reviewed, no exposure limits for aluminum phosphide are shown here. Current exposure limits for these fumigants may be obtained from the FGIS Safety Staff. Collateral duty safety and health officers should be aware of the latest exposure limits for aluminum phosphide.