

University of Nebraska - Lincoln

DigitalCommons@University of Nebraska - Lincoln

Historical Materials from University of
Nebraska-Lincoln Extension

Extension

1986

G86-790 Fumigating Farm-stored Grain With Aluminum Phosphide (Revised May 1998)

Clyde Ogg

University of Nebraska - Lincoln, cogg1@unl.edu

David L. Keith

University of Nebraska-Lincoln, dkeith1@unl.edu

Follow this and additional works at: <https://digitalcommons.unl.edu/extensionhist>



Part of the [Agriculture Commons](#), and the [Curriculum and Instruction Commons](#)

Ogg, Clyde and Keith, David L., "G86-790 Fumigating Farm-stored Grain With Aluminum Phosphide (Revised May 1998)" (1986). *Historical Materials from University of Nebraska-Lincoln Extension*. 1223. <https://digitalcommons.unl.edu/extensionhist/1223>

This Article is brought to you for free and open access by the Extension at DigitalCommons@University of Nebraska - Lincoln. It has been accepted for inclusion in Historical Materials from University of Nebraska-Lincoln Extension by an authorized administrator of DigitalCommons@University of Nebraska - Lincoln.



Fumigating Farm-stored Grain With Aluminum Phosphide

This NebGuide provides step-by-step instructions for fumigating stored grain on the farm with aluminum phosphide.

Clyde L. Ogg, Pesticide Education Specialist
David L. Keith, Extension Entomologist

- [Application and Distribution of Aluminum Phosphide](#)
- [Equipment Needed](#)
- [Cautions](#)

Fumigants act on all insect life stages. They control pests by diffusing through the air spaces between grain kernels as well as into the kernel itself. Fumigants are able to penetrate into places that are inaccessible to insecticide sprays or dusts.

Regardless of formulation, all fumigants are poisonous and toxic to humans and other warm-blooded animals as well as to insects and other pests. Because fumigant chemicals are highly toxic and hazardous to use, they are Restricted Use pesticides. They can only be used by certified applicators. This NebGuide is designed to help farmers who have a private pesticide applicator license and want to do the fumigation themselves. *Methyl bromide should only be applied by trained professional fumigators because of distribution problems and the extreme hazards involved with its use.*

Aluminum phosphide is formulated in tablets, pellets, paper sachets, plates, and blister strips. The tablet or pellet formulations are most suitable for farm applications. Solid aluminum phosphide formulations release hydrogen phosphide (phosphine) gas when exposed to moisture and heat. Warm, humid air accelerates the reaction while cool, dry air slows it down. The reaction starts slowly, gradually accelerates and then tapers off.

Application and Distribution of Aluminum Phosphide

Aluminum phosphide tablets and pellets may be applied to the grain mass by probing them below the grain surface, adding them as the grain is turned, or placing them in the aeration ducts below the grain mass. Treatment during turning of the grain is not generally feasible in on-farm storage and often alternative methods must be used to treat the grain in place. In shallow bins, tablets may be probed into the grain using a

5- to 7-foot long hollow tube designed for this purpose. These tubes can be purchased or made from electrical conduit or plastic pipe according to the distributor's recommendations.

The following is a step-by-step description of a typical probe application of aluminum phosphide to grain in a circular steel bin.

Equipment Needed

- Proper respiratory protection for all involved in the fumigation. Check fumigant label for specific requirements.
- Man-in-Bin sign placed near the control panel.
- Tape measure to calculate volume of grain to be treated.
- 2-6 ml polyethylene film cut to the size of grain surface to be covered. A rope should be attached for easy removal after fumigation.
- Cotton gloves for handling phosphine fumigant.
- All fumigations should be done by at least two people.
- Probes made from 1/2- or 3/4-inch electrical conduit or rigid PVC pipe for applying aluminum phosphide tablets.
- Safety rope for anyone climbing into a bin.
- Shovels to level grain mass.
- Grain thermometer to measure grain temperature throughout the grain mass.
- Warning signs for the fumigant being used.
- Lock to keep unauthorized personnel out of building being fumigated.
- Monitoring equipment to check gas concentration.
- 2- or 3-inch masking tape, spray adhesive, adhesive for polyethylene sheets.
- Instruction manual and current label.
- Dosage chart.
- Sufficient fumigant.

Level The Grain

Level the grain surface and break up any crusted areas that may have formed. When grain is peaked, the action of fumigants is similar to rain on a hillside. The heavier-than-air gases simply slide around the peak, resulting in poor penetration and survival of pests in the peaked portion of the grain.

Moldy or crusted areas near the grain surface are generally caused by moisture condensation when warmer air in the grain rises to the surface and encounters cold air above the grain. These areas are sometimes hidden from view just below the grain surface. Failure to locate and break up these areas will result in uneven penetration of grain fumigants and may lead to further deterioration of the grain from mold development and invasion of the grain by insects that feed on grain molds.

Seal The Bin

Sealing the bin is the single most important step in fumigation. Attention to proper sealing of grain bins before fumigation will often make the difference between success or failure. A high degree of air and gas tightness is essential to achieve and maintain the required combination of gas concentration and exposure time necessary to kill grain pests.

Metal storage bins are not gas tight. Many were originally designed to hold and aerate grain, however, and can be used for fumigation with proper sealing. It is important to recognize that bins will vary in tightness depending upon how well they were built. If the corrugated sections were caulked when put together, and then bolted, they will be more gas-tight. Loosely constructed wooden bins may have to be totally covered

with a gas-tight tarpaulin to retain enough fumigant to be effective.

Grain in flat, storage-machine-shed type buildings should be covered with a tarpaulin for maximum effectiveness.

Remember, the goal is to confine the gas long enough at the proper concentration to be lethal to the target pests. *Sealing is extremely important* and demands study and work. Several techniques can make the seal more effective.

There are several places in a bin where gas can escape. The roof-wall junction may look tight from the outside, but examination from the inside may reveal a gap around the perimeter in many bins. This gap is difficult to seal because it is usually dusty and may be damp. Cracks wider than 1 inch are even harder to seal. Clean the dust from the surfaces before applying tape or other sealing material. Professionals will clean the surface first and then spray it with an adhesive dispensed from a pressurized can. The gap is then sealed with duct or furnace-cloth tape. Use at least 2-inch and preferably 3-inch wide tape when sealing these cracks.

An expensive but useful tool is the pressurized can of tape primer. It is available from the fumigant distributor or sometimes from an auto paint store. This primer can make the tape's surface tacky and improve the holding quality. It can also be applied to the tape's adhesive surface to improve its sticking power.

Polyurethane foams can be used to seal gaps, but they are expensive and difficult to remove if the gap is needed for extra grain aeration. Though insects occasionally can burrow into the foams and destroy their effectiveness, they usually provide a good seal for several years.

Another key area to seal is the gap between the bottom of the wall and the floor. Some manufacturers design the wall base to accept a special sealant that can give a long-term seal. Various sealing materials have been used, including one made with polyurethane impregnated with asphalt. Plain asphalt also has been used on the outside but does not have as much elasticity.

Roof ventilators must be covered with plastic bags. The bags are less likely to tear against sharp edges if a burlap bag is placed over the ventilator first. The plastic bag should be gathered in at the base and then taped in place. Avoid coming in contact with electrical wires when doing this.

Bin doors are not gas tight when merely closed. They can be cleaned and sealed with duct tape, or if not used regularly, they can be sealed with foam-in-place plastic.

Aeration fans and housings must be sealed to avoid gas loss. Normally, polyethylene glued to the air intake will be sufficient, however, the unit should be examined for other potential leaks.

Determine Dosage

Determine the number of tablets required to treat the volume of grain in the bin and the head space.

Since hydrogen phosphide is a mobile gas and will penetrate to all parts of the storage structure, dosage must be based upon the total volume of the space being fumigated and not on just the amount of grain.

Decrease the dosage if the bin is exceptionally gas tight, or contains clean, dry grain.

Follow label instructions for dosage determinations.

Calculate Dosage

All fumigant labels provide information on the recommended dosages required to effectively treat stored

grain. Using less fumigant than recommended can result in a concentration of gas too low to be effective. Using more fumigant than recommended is illegal, adds unnecessary cost, and may not increase efficiency.

Use the following formulas to calculate the number of bushels in a bin.

$$0.6283 \times \text{diameter}^2 \text{ (ft)} \times \text{grain depth (ft)} = \text{number of bushels in a round bin}$$

$$0.8 \times \text{length (ft)} \times \text{width (ft)} \times \text{grain depth (ft)} = \text{number of bushels in a square or rectangular bin}$$

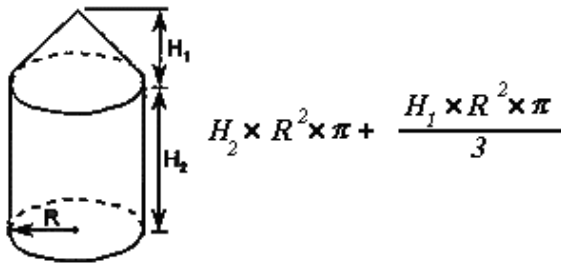
Example. A bin has a diameter of 10 feet, and the grain depth is 8 feet. How many bushels are in the bin? Using the formula above, and plugging in the known numbers:

$$0.6283 \times 10^2 \text{ (ft)} \times 8 \text{ (ft)} = \text{number of bushels in a round bin}$$

$$502.6 = \text{number of bushels in a round bin}$$

Use the following formula to calculate the total volume of a grain bin.

Volume of a tent-shaped roof and cylinder space =



Example: A bin has a radius (R) of 5 feet, the ridge height (H₂) is 10 feet, and the total height (H₁ + H₂) is 15 feet. To determine H₁, subtract H₂ from 15 (15 - 10 = 5). Pi (P) is approximately 3.14. Using the formula above, and plugging in the known numbers:

Volume of a tent-shaped roof on cylinder space =

$$10 \times 5^2 \times 3.14 + \frac{5 \times 5^2 \times 3.14}{3}$$

Volume of a tent-shaped roof on cylinder space =

$$\frac{785 + 392.5}{3}$$

Volume of a tent-shaped roof on cylinder space = 915.83 cubic feet

Dosages recommended for the various phosphine-producing fumigant formulations are fairly similar. However, the actual amount of phosphine involved in specific fumigations will vary depending on the type of structure to be treated. Because phosphine distribution is not materially affected by being taken up by the

grain, application rates are based primarily on the gas tightness of the structure and the method of application.

Dosages for aluminum phosphide formulations are expressed in terms of tablets per 1,000 bushels storage capacity or 1,000 cubic feet of space.

Post Warning Signs

The applicator must post warning signs at all entrances to the fumigated area. These signs must contain:

1. the words "DANGER/PELIGRO";
2. the SKULL AND CROSSBONES symbol in red, and
3. "Area and/or commodity under fumigation, DO NOT ENTER/NO ENTRE".
4. It must also contain the statement: "This sign may only be removed after the commodity is completely aerated (contains 0.3 ppm or less phosphine gas). If incompletely aerated commodity is transferred to a new site, the new site must also be placarded and workers must not be exposed to more than 0.3 ppm phosphine."

The sign must also contain the date and time fumigation begins and is completed, name of fumigant used, and the name, address, and telephone number of the applicator.

Apply the Aluminum Phosphide Tablets

Divide the total number of tablets needed by four to place in each pie-shaped quarter of the bin. Typically, the number would then be divided by five (the number of tablets per probe) to determine the number of probes needed per quarter. For example, if the total number of tablets required for the bin is 280, the number for each quarter is 280 divided by 4 which equals 70 per quarter section. Each section would be probed 14 times with 5 tablets in each probe.

When placing the tablets in the probe, place the first one when the probe is down 5 feet, then raise it 1 foot, and place the next tablet in the probe. Continue until five tablets are placed. The last tablet should be about 6 inches from the surface.

As many as 20-50 tablets may be released at one probe site; however, releasing all the tablets at once may slow the release of gas and may cause an explosion.

Arrange for enough applicators and other workers to complete the job quickly to avoid excessive exposure to phosphine gas. The production of gas during application can be reduced by opening the flasks outdoors and conducting fumigation when temperature in the bin is lowest.

Applicators should work in pairs and be properly fitted with respiratory devices.

Provide Respiratory Protection

The permissible gas concentration ranges (based on eight hours, time weighed average) for various types of respiratory protection devices are:

<i>Gas Concentration</i>	<i>Respiratory Protection</i>
Less than 0.3 ppm	None required
0.3 - 15 ppm (or escape from levels up	NIOSH/MSHA-approved full face gas mask-hydrogen

to 1,500 ppm)

phosphide canister combination

More than 15 ppm

NIOSH/MSHA-approved self-contained breathing apparatus (SCBA)

If monitoring equipment is not available and the gas concentration is unknown, a NIOSH/MSHA-approved self-contained breathing apparatus is required.

If monitoring equipment is not available and the application cannot be done from outside the structure, an approved canister respirator must be worn during application from within the enclosed indoor area.

Seal the Doors

After all sections of the bin have been probed, close the bin and seal the access point with duct tape or plastic glued into place. This seal prevents fumigant vapors from venting to the outside and prevents the wind from drawing the fumigant out of the grain. Gas loss can be reduced by placing a polyethylene sheet cut to size over the grain before sealing the door. Fasten a rope to this sheet so it can be removed safely after the fumigation. Remove the plastic immediately after the fumigation is complete to prevent moisture condensation and avoid hindering aeration. Use proper respiratory protection when removing the plastic. The rest of the bin still needs to be well sealed for best results.

Also Consider

When the grain temperature is considerably warmer than the outside air, or the grain is more than 12-15 feet deep, the fumigator may place as many as 25 percent of the tablets in the aeration system. Tablets or pellets should never be stacked on top of each other. **Never place aluminum phosphide on a wet surface or in standing water since it would evolve the gas too fast and could possibly ignite or explode.** Once aluminum phosphide tablets or pellets have been exposed to air, they should not be resealed since they may ignite or explode spontaneously. Be sure to seal fan opening.

Determine Length of Fumigation

The exposure time of the phosphine gas in the grain must be long enough to provide for adequate control. Lengthen the time at lower temperatures because insects are more difficult to kill under these conditions.

Table I. Guide to determine the minimum length of exposure¹ for aluminum phosphide.		
<i>Temperature to which fumigant and/or insects are exposed</i>	<i>Pellets</i>	<i>Tablets</i>
Below 40°F	Do not fumigate	Do not fumigate
40°F - 53°F	8 days	10 days
54°F - 59°F	4 days	5 days
60°F - 68°F	3 days	4 days
Above 68°F	2 days	3 days

¹As a rule-of-thumb a minimum of one day should be added to the exposure time listed above for each 10 feet the gas must penetrate downward. It is preferable to add 2 days to each 10 feet.

Spray Bin Exterior

Spray the outside of the bin after applying fumigant and sealing the bin. Use premium grade malathion, methoxychlor, or Reldan, and spray to the point of runoff. Always read and follow all instructions on the product label.

Aeration and Re-entry

If the area is to be entered after fumigation, it must be aerated until the level of hydrogen phosphide gas is 0.3 ppm or below. Remove the plastic covering the grain surface immediately after fumigation even if the bin is not to be aired out. The area or site must be monitored to ensure that liberation of gas from the treated grain does not result in the development of unacceptable levels of hydrogen phosphide. Do not allow anyone to enter treated areas before this time unless protected by an approved respirator.

After the bin is aired out, treat the grain surface with an approved grain protectant to reduce insect reinfestation and kill any flying insects in the space above the grain.

At the end of a phosphine fumigation, the powdery residue of tablets or pellets will still contain a small amount of undecomposed aluminum phosphide for several additional days. Under normal circumstances of grain handling, these residues do not present a hazard, but inhalation of the powder should be avoided.

Determining concentrations. It is very important to monitor the fumigant concentration to determine any losses due to sorption or leakage so that adjustments can be made if necessary. It may be necessary to reseal an area, add more gas, or lengthen the exposure period to give the proper concentration of fumigant for the necessary time. After the fumigation is over, it is equally important to be able to know that the gas has been reduced to a level below the eight-hour Time Weighted Average (0.3 ppm) to ensure worker safety upon reentry.

There is no single device that can economically and efficiently measure all fumigants at all normal levels. Various devices can be used depending on the gas being measured and whether a high reading during the fumigation or a low-range reading for compliance with the Time Weighted Average after the fumigation is needed. Follow instructions for the particular device you use.

Detection tubes are probably the most versatile tools available for measuring gas concentrations. They are available for many industrial gases as well as almost all fumigants. The equipment used with the tubes is well built, durable, and manufactured by a number of suppliers. The initial equipment cost is moderate and can be amortized over hundreds of uses and many years. For most gases, they are sufficiently accurate.

The disadvantages to using these tubes is that they are designed for a single use on a single type of fumigant. Their cost can be burdensome when many readings are needed. They are not available for both high and low readings so separate tubes of different capacities must be used. The tubes have a limited shelf life and are not reliable after the expiration date. In addition, they have limited accuracy on some gases.

Plastic tubing must be placed so that air within the bin may be sampled from outside the bin.

Cautions

- All fumigants are dangerous if improperly used. Follow the cautions listed on the container label and use only in strict accordance with label directions.
- Wear respiratory protection approved by NIOSH/MSHA for the level of hydrogen phosphide gas to which you will be exposed.
- The effective life of a gas mask canister is limited. Keep an accurate account of the time that a canister is used and replace it after each use, if you smell fumigant, or the canister is out-dated.

- A self-contained breathing apparatus requires a refilling source. Your local fire station or rescue squad may be a refill source.
- **Never fumigate a bin by yourself.** Have one or more people on site to help if you get into trouble. The helper(s) must also be properly fitted with approved respiratory protective devices. Devise a code so that you can communicate with one another. Make sure gas and electrical connections are turned off. Have the telephone numbers of the police and fire departments, hospital, physician, and rescue squad available.
- Do not drink alcoholic beverages for a day before, during, or after exposure to grain fumigants. Do not think that because you might have gotten away with fumigations without these precautions before that you can always get away with disregard to safety. Fumigants demand respect if you want to avoid injury or death.
- **If there are differences in statements in this NebGuide and the aluminum phosphide label, follow the label instructions.**

*File G790 under: PESTICIDES, GENERAL
A-1, Insecticides, 22,000 printed
Revised May 1998*

Issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture. Elbert C. Dickey, Director of Cooperative Extension, University of Nebraska, Institute of Agriculture and Natural Resources.

University of Nebraska Cooperative Extension educational programs abide with the non-discrimination policies of the University of Nebraska-Lincoln and the United States Department of Agriculture.