Integrated Pest Management and Fumigation Safety Training

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Practical Phosphine Fumigations

Jerry Heath, BCE
Recall that fumigant effectiveness depends upon achieving and holding a certain concentration for a minimum exposure time.

Concentration will depend on:
- Dose (plus extra allowance to make up for leakage).
- Air circulation assistance to achieve equal concentration throughout.

Exposure time requires:
- Sealed space capable of holding gas adequately.
- Commitment to give the job the necessary time.
Solid Fumigant Packages and Gas Potential

- Each AlP pellet weighs 0.6 g and can produce 0.2 g phosphine gas.
- Each Tablet: about 3 g weight and 1 g phosphine gas.
- Each solid fumigant prepac or package size has known gas potential.
- 1 g phosphine = 25 ppm in 1000 cu. ft.
Metal Phosphide Gas Evolution

$\text{AlP} + 3\text{H}_2\text{O} \rightarrow \text{Al(OH)}_3 + \text{PH}_3$

Or

$\text{Mg}_3\text{P}_2 + 6\text{H}_2\text{O} \rightarrow 3\text{Mg(OH)}_2 + 2\text{PH}_3$

- Reactions require moisture* and heat.
- Magnesium phosphide reaction goes faster.

* Moisture is key to certain safety issues. Avoid accidental water contact or water for firefighting!
Phosphine gas is spontaneously combustible at 18,000 ppm!

- Not likely a concern under normal fumigation conditions.
- Excessive or accidental water contact (firefighting, water puddles, etc.) can cause uncontrolled, fast gas production to explosive levels.
- Improper waste collection and confinement is a critical mistake.
- Wet deactivation should be under controlled conditions.
Goal: Utilize slow release formulation (Tablet), sealing and dosage to keep red line above minimum concentration for time necessary.
What we know about PH$_3$ C-T requirements

- Do not fumigate when commodity or space temperature is below about 15 C. Insects are not sufficiently active.
- US: 15 – 20 C: Need minimum 300 ppm for 100 hours.
- US: 20 C +: 200 ppm minimum for 100 hours.
- Tough targets or insects known to be resistant require higher concentrations or longer exposures!

This is emerging knowledge. Product manuals are not much help.

- Australians recommend 100ppm or higher for 2 week exposures!


Dosing is fundamentally according to space or volume

But if we know weight or numbers of bags we can sometimes use a conversion to volume.

Best to figure out your own conversion factors by computing volumes of some neat tarped stacks of known weights, and then the weight per cubic meter.

For odd shaped stacks always estimate or err on the side of greater volume. A little higher dose is better than too little.

Round up to full-flask dosages because partial flasks cannot be stored safely.
Phosphine Tablet & Pellet Product Manual Suggests Range of Doses

Above 20 C: 3 days minimum exposure time for tablets. *(Experts suggest longer exposure time.)*

Dosage advice for different types of sealed enclosures:

- “Bulk commodities in covered bunkers”: 70-145 Tabs per 1000 cu. ft.
- “Vertical silos”: 30-140 tabs / 1000 cu. ft.

Point is, there is a broad range of recommended dosages.

3–4 Tablets/ton your standard?

This appears to fall in the middle of manufacturer’s recommended dosage range.
Adjust According to Your Situation!

- Tough insects, possibly resistant?
- Uncertain diffusion of fumigant throughout stacks?
- Quality of seal to hold gas concentration for 4 - 14 days? Condition of your tarps? How do your seams compare with previous pictures?
- How much hold time can you afford? *Increasing your exposure time is probably single best improvement you can make!* You may also need to allow a couple days for aeration.
Pesticide exposure can be by 3 possible routes:
- Oral
- Dermal
- Inhalation

For most pesticide users dermal exposure is the greatest concern, but for fumigators the **hazard is inhalation**.

Fumigants are all *highly toxic* by inhalation.
Gas Monitors for Safety
Be sure to specify PH₃ low-range models!

Detector tubes:
- Single point in time. Expensive: about $10 USD per reading.
- Slow to use; Require reading and interpretation; Glass hazards.

Electronic Monitors:
- Continuous reading. Automatic.
- More economical for regular use.
- Draeger Pac 7000, about $650 USD.
Respiratory Protection

- Full face respirator with cartridge designation for PH.
  - NOT a dust mask, or simple P-100 rating!
  - Keep clean and available if needed.
  - Cartridge svc life about 40 hrs. of use.

- Self Contained Breathing Apparatus (SCBA)
  - Select “industrial” models rather than fire svc. (Need probably limited to professional fumigators)
Mild poisoning symptoms:
   Feeling sick, ringing in ears, fatigue, nausea, pressure in chest.

Simple 1st Aid:
   *Fresh air!*

Normally no lasting harm.

Hopefully you never have experience with poisonings. If you do, protocols need to be fixed.

In the event of any pesticide poisoning requiring medical care, provide a label document for important reference information.
Recognize variations in acceptable phosphine fumigation methods

Almost any kind of containment or space that can be sealed can potentially be fumigated.

Tarped fumigations and container fumigations are your most likely types.

There can be potential variations in acceptable tarps or sealing methods: poly sheets vs. multi-use tarps, floor seals?, sand snakes vs. tape/glue seals, etc.
FMP: Application Planning for Safety & Efficacy in advance

- Notify neighboring and affected people in advance as necessary.
- Think ahead to aeration and consider staging supplies and equipment that may be needed.
- Be prepared with all necessary supplies. Use a checklist.
- Make every possible preparation. Have everything set.
- Post placards immediately before the application.
- Organize efficient teamwork for the actual application and final tarp seal. Plan to be out the door ASAP after the first flask is opened!
- Final placarding and security to keep people away.
1. Warning sign or placards should be deployed before work begins. Respiratory protection gear should be readily available in case needed.
2. Compute dosage for the stack. Figure how many dosing points there will be around bottom edge or possibly other positioning.
3. Residual insecticide often applied around bottom of tarped stack.
4. Positions tarp rolls over stack so there will be overlap for rolled seams and tarps will reach to floor and outwards on floor surface for at least a meter.
5. Tarp seams pulled together: one side folded up and over about 1 meter on itself; the other overlapping the fold. Then rolled together to seal on top and sides. Seams may or may not need to be clipped indoors. Fold neatly down sides, around corners and onto floor.
6. Sand snakes positioned to seal tarp to floor. Or, glue/seal methods.
7. Monitor with detection equipment in case respirators become needed.
8. **Clock is about to start running for quick completion of placement and seal and exit so good teamwork is required.** Fumigant flask(s) opened and dispensed to dosing positions in dishes/trays. Complete seals to floor at dosing points.
9. Exit, lock up and double check that warning signs are in place and all entrances are secure.
Aeration Phase Safety

- Potentially the most dangerous time during fumigations: purposely entering dangerous atmospheres.
- Be aware of wind direction and where gas will drift.
- Have safety monitors and respirators available.
- Plan teamwork for a fast and efficient initial opening for aeration. Allow time for concentrations to drop before attempting complete cleanup.
- Beware atmosphere may seem safe, but desorption from bags and grain mass could take several days. Building concentrations could return to dangerous levels if doors and windows are closed.
Container Fumigations & Unloading

- Have detection and respiratory protection equipment readily available.
- Open doors and allow to ventilate. Remove spent fumigant, etc.
- Workers in fresh air will normally be in safe atmospheres.
- Containers may need to be unloaded gradually as nose of container will be slower to aerate.
Deactivation/Disposal of Waste

“Spent” fumigant is often removed from fumigations before reaction is 100% complete. Need to be careful not to confine and cause fire! Then, what to do with hazardous material?

- **Dry deactivation** is preferable! Give material time to react at its own pace.
- **Wet:** Quickly & completely immerse waste in a full barrel of water. Violent & messy process... Allow time to soak.
- Deactivated clay waste usually buried on site.
Questions or Discussion?

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