

Unit 5: Methods of Fumigation

Learning Objectives

After studying this unit, the reader will be able to:

- Describe several methods of fumigation.
- Discuss the pros and cons associated with each method.
- Select the most appropriate fumigation method for a particular situation.
- Understand the importance of proper aeration.
- Safely and effectively aerate structures and fumigated areas following treatment.

This unit describes three of the most common fumigation methods: vault, tarpaulin, and spot fumigation. Each method has advantages and disadvantages. You will learn what these are and how to use this information to select the best type of fumigation for a particular situation. This unit also discusses the importance of proper aeration. You will learn about factors that affect the speed of aeration. You will also learn how to perform these procedures yourself.

Terms to Know

Absorption – When fumigant molecules penetrate into a material (commodity, structure, or other item being fumigated).

Adsorption – When fumigant molecules stick to the surface of a material (commodity, structure, or other item being fumigated).

Aeration – When fresh air is introduced to dilute and remove fumigant-filled air. Aeration must follow all fumigation operations.

Air Wash – A method of aeration used in vacuum fumigation. Air washing involves drawing a second vacuum after the exposure period is complete and then breaking this vacuum with fresh air.

Billowing – When air or gas causes something to bulge outward. In tarpaulin fumigation, this occurs when gusting winds cause a tarp to bulge away from the item or structure that it is covering.

Blower – A machine that generates and directs an air stream in a particular direction.

Boxcar – A large, roofed container with enclosed sides used to transport freight. Boxcars usually have sliding doors on each side. Trains usually transport boxcars.

Desorption – The liberation or removal of a fumigant from other substances.

Diffusion – The process of spreading out or distributing evenly in a space.

Dosage – The concentration of a fumigant (ounces, ppm, etc.) x the exposure time (hours, minutes, etc.). The dosage requirements depend on the pest, the fumigant, the temperature, the rate of leakage (some leakage is inevitable), and many other factors.

Fumigation Tape – Strips of adhesive material used to seal doorways, windows, and other areas where gas might escape during fumigation. You can also use fumigation tape to join together two or more tarps during tarpaulin fumigation. Fumigation tape has a plastic or vinyl coating that reduces fumigant penetration.

Fumiport – A special opening in a transfer line, small bin, or food processing machine through which you can apply fumigants.

Gas Detector – A device used to check the concentration of fumigant in the air.

Gastight – Something that does not allow gas to enter or pass through. Gasproof.

Ground Seal – The sealing of tarps to the ground to prevent fumigant loss during fumigation.

Nonsparking Fan – A machine that safely recirculates air in potentially explosive environments.

PPM (Parts Per Million) – The number of parts of a substance in one million parts of another substance. For example, if a gas detector reads “5 ppm” it means that there are five parts of fumigant to every one million parts of air.

Prepac – Aluminum phosphide fumigant tablets that are packed in a gas-permeable material.

Process Stream – A commodity that is enroute to a storage facility.

Respirator – A device that protects the respiratory tract from irritating and poisonous gases, fumes, smokes, and dusts. Respirators may or may not have equipment that supplies oxygen or clean air.

Seal – To enclose an area so that fumigant gas cannot escape too quickly. A good seal will contain a lethal amount of gas for long enough to kill the target pests.

Self-Contained Breathing Apparatus (SCBA) – A type of respirator that supplies fresh air from an outside or portable source. Air enters a mask that tightly covers the entire face.

Sorption – Adsorption and/or absorption.

Tarpaulin – A semipermeable material used during fumigation to confine fumigant in a specific area during the exposure period.

Once you pinpoint a pest problem and decide fumigation is necessary, you are ready to choose a treatment method. There are several types of fumigation. Each has its pros and cons. Your job is to select the best method for a given situation. Your decision will be based on:

- The item, area, or structure you need to treat
- The location of the item or construction of the structure
- The budget of your client
- The proximity of the treatment area from other people
- Weather conditions, and
- The severity of the infestation

This unit describes the most common methods of fumigation used to treat food and stored products. You will learn how and when each method is normally used. You will learn how to implement each method. You will also discover basic safety considerations associated with each method. With this information, you can make educated decisions.

This unit also discusses aeration procedures. Aeration “airs out” or removes fumigant from an

item or location following treatment. Aeration must follow all fumigation operations. However, aeration procedures differ depending on the method of fumigation used and the site treated. This unit will explain several aeration techniques.

Remember that fumigation is highly toxic and dangerous. It is reserved for only the most severe infestations. Be sure fumigation is the best option for your situation.

Types of Fumigation

The challenge of fumigation is to achieve and contain an adequate concentration of toxic gas long enough to obtain pest control. You can do this by using one of three methods of fumigation.

- **Vault Fumigation** – Vault fumigation uses atmospheric or vacuum chambers to treat infested commodities. Vaults may include trucks, boxcars, ship holds, warehouses, and other structures.
- **Tarpaulin Fumigation** – Tarpaulin fumigation places items under a tarp or covers an entire structure. Fumigant is released beneath the tarp and held until pest control is complete.
- **Spot (Local) Fumigation** – Spot fumigation is used to treat small items or areas with light to moderate infestations. Spot fumigation is also used routinely to prevent infestations from developing or recurring.

Vault Fumigation

Vault fumigation treats infested items within an airtight or sealed structure. These structures or “vaults” may serve dual purposes such as truck trailers, boxcars, or ship holds. Others, like vacuum chambers, are specially designed for fumigation. Sealed buildings and flour bins are also fumigation vaults. While you must take basic safety precautions, fumigation in atmospheric vaults and vacuum chambers poses fewer risks than other methods. These structures are better designed to deliver, contain, and exhaust the fumigant.

For simplicity, this unit will discuss three types of vault fumigation:

- Fumigation in atmospheric chambers
- Fumigation in vacuum chambers, and
- Fumigation in sealed structures

Atmospheric Chambers

An atmospheric chamber can be any airtight structure under normal air pressure. They are usually small buildings located away from other structures. Some are specially built for fumigation. Others are modified from existing structures.

You can construct a suitable, low-cost atmospheric chamber using a gastight room with an appropriate door. A minimum of equipment is required. You will need tools to apply, distribute, and remove the gas. Heating may also be necessary. Steam pipes are best and should be able to heat the area to 70°F during treatment. Locate the chamber so that you can easily move goods in and out of it. Also, be sure to minimize hazards to workers and the environment. Atmospheric chambers should not be within or connected to other structures where fumigant passage may occur.

Advantages of Atmospheric Chambers

Once built or modified for fumigation, you can use atmospheric chambers again and again. Commodities can be moved in and out of the vault without special preparation. Vaults have a constant volume, so you do not have to compute the volume for each treatment. You can permanently install special equipment to monitor fumigant levels.

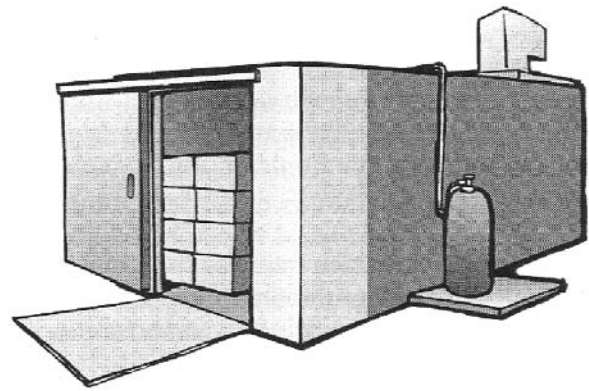
Disadvantages of Atmospheric Chambers

Atmospheric chambers are costly to set up and hold a limited number of items. It also takes time and money to move commodities in and out of the chamber.

Vacuum Chambers

Vacuum chambers are large, steel structures. Unlike other vaults, treatment occurs in a “vacuum” rather than at atmospheric pressure. In a vacuum, air pressure is lower. This does two things.

First, it denies oxygen to the pest. Under a vacuum, the oxygen level inside a chamber decreases. Pests become stressed and are easier to kill. Second, the vacuum helps the fumigant



Atmospheric Vault

penetrate the commodity. This may reduce fumigation time from 24 hours to 4 1/2 hours depending on the fumigant used. In addition, by adding an “air-wash cycle” (breaking the vacuum and drawing a second vacuum), aeration after treatment is also fast. Despite its benefits, beware. Some fumigants (such as phosphine) explode under vacuum conditions. Always read the label information to be sure your product is safe to use in a vacuum chamber.

Vacuum fumigation is used to treat densely packed items and other materials that are difficult to penetrate at atmospheric pressure.

There are two main ways to conduct vacuum fumigation: sustained-vacuum fumigation and restored-pressure fumigation. The “sustained-vacuum method” starts when you reduce the pressure inside the chamber and introduce the fumigant. The slightly reduced pressure (vacuum) is held until the end of the treatment. In the “restored-pressure method,” you would lower the pressure, introduce the fumigant, and then restore the pressure in one of four ways.

1. **Gradual Restoration** – Release the fumigant and then slowly introduce air until the air pressure returns to normal. This usually takes two to three hours.
2. **Delayed Restoration** – Hold the vacuum for about 45 minutes following discharge of the fumigant. Then, allow air to rapidly enter the chamber.
3. **Immediate Restoration** – Just after releasing the fumigant, rapidly let air into the chamber by opening one or more valves.
4. **Simultaneous Introduction of Air and Fumigant** – Use special metering equipment to release a mixture of air and fumigant into the chamber.

These four techniques to restore pressure are listed in order of effectiveness – number one being the most effective for most situations. The “sustained-vacuum method” falls between methods two and three.

“Air-washing” must follow all vacuum fumigation procedures. This process removes the fumigant/air mixture, and then flushes the chamber with clean air several times until it is safe to open the door for unloading. Air-washing is more intensive than aeration. Because vacuum fumigation forces fumigant into a commodity, adsorption of that chemical is strong. Without forcing fresh air into the chamber, the fumigant may remain within the commodity.

Vacuum fumigation requires the same safety precautions as other fumigation methods. These may include wearing a respirator and using monitoring tools to test for leaks. See Units 6 and 7 to learn more about fumigation safety.

Portable Vacuum Chambers

When you need to fumigate small items or commodities in several locations, a portable vacuum fumigation system brings added flexibility. A portable unit consists of:

- A vacuum such as a “shop vac” or other high-capacity vacuum cleaner
- Two pieces of heavy-duty vinyl sheeting that you can clamp or zip together (similar to food storage bags)
- Fumigation dispensers
- Connecting hoses
- A security lock
- A gas concentration monitoring valve
- A carrying case, and
- A gas discharge standpipe

Portable systems allow you to develop a vacuum between the layers of vinyl. The vacuum pulls the vinyl tight around the commodity. Once the vacuum reaches the optimal level, you can apply the fumigant.

Advantages of Vacuum Fumigation

Commodities fumigated in vacuum chambers require much shorter exposure times. The fumigant can penetrate dense commodities. Vacuum chambers have most of the other advantages of atmospheric chambers.

Disadvantages of Vacuum Fumigation

Vacuum fumigation in chambers takes a large initial investment. Commodities must be moved into and out of the chambers. You cannot use phosphine or other fumigants that are explosive under a vacuum. In addition, more fumigant is required, and the number of commodities that can be fumigated in vacuum chambers is limited.

Structural Fumigation by Sealing

There are two types of structural fumigation: structural fumigation by sealing also called “tape and seal” fumigation (a type of vault fumigation) and structural fumigation by tarping (a type of tarpaulin fumigation).

Both methods work by turning an entire structure – warehouse, boxcar – into a temporary fumigation chamber. To do this, it helps if the building is airtight. Structural fumigation by sealing accomplishes this by working only with buildings that are in good repair. Workers find and seal all leaky spots with fumigation tape. The goal is to create a “vault” that is as close to airtight as possible. Structural fumigation by tarping creates an airtight environment by placing a tent over the entire structure. See “Tarpaulin Fumigation” later in this unit for more information on this method.

Both types of structural fumigation are most often used to treat homes, warehouses, wheeled carriers, and other structures with severe infestations.

Structural fumigation by sealing allows you to treat many building types. You can fumigate brick, concrete, and stucco buildings in good repair if you tape and seal them first. You may need to tarp the roof if it is likely to leak. Monitor the fumigant concentrations to ensure an adequate dosage (concentration of fumigant x exposure time) is achieved to kill the target pest. In addition, you must run gas detectors throughout the structure to monitor fumigant levels in different areas. This will ensure that all areas receive an equal dosage of fumigant.

Advantages of Structural Fumigation by Sealing

Before treatment, you need to remove from the building only contents (or items) that may be damaged by the fumigant.

Outside shrubbery is usually not at risk of exposure. Nontarget pests such as rats and mice are usually controlled along with the insects. In addition, little material is needed to make the structure relatively airtight. Unfortunately, this advantage is usually offset by the labor required to find and seal leaks.

Disadvantages of Structural Fumigation by Sealing

Building occupants must leave the structure during treatment. You must also remove items that the fumigant may damage. Tape and seal fumigations are notoriously leaky. It is easy to overlook vents, cracks, conduits, and other areas that may permit gas to escape. The fumigant may diffuse through interior walls, making it hard to maintain the required concentration of gas. Insects in the exterior walls and eaves may survive if gas levels are too low to penetrate these sites.

Once you decide that structural fumigation is necessary, do a thorough on-site inspection. Frequently, the success of a fumigation operation will depend on what you learn, what you decide, and how you plan. Ask yourself a number of questions.

Preparing for Structural Fumigation

General

- If the structure itself is not infested, could you move the infested item(s) and treat it elsewhere? If removing the infested item(s) is not practical, can you fumigate it in place without treating the entire structure?
- What is the volume (cubic feet) of air space or volume (cubic feet) of the commodity? What is the cubic footage of the building? (See Appendix B for information on how to calculate volume.)

Inside the Building

Are there any broken windows that you need to replace? Are there cracks in the ceiling, walls, or floor that you will need to seal? Are there

floor drains, sewer pipes, or cable conduits that may leak? There have been a number of fumigation failures because floor drains under stacked commodities went unnoticed. In another case, a fumigant leaked into a telephone cable tunnel that led to an occupied building. A number of people became ill.

- How will you handle air conditioning ducts and ventilation fans?
- Are there any fireplaces, flues, or stovepipes?
- Will interior partitions interfere with fumigant circulation?
- Are the interior partitions gas tight?
- Can you rely on them to keep the fumigant from entering other parts of the structure?
- Are there parts of the building that are not under the control of your customer?
- Can you shut down these operations during treatment?
- Will the fumigant damage anything in the building?
- Can you remove these items during fumigation? If not, can you protect them?
- Where are the gas shut-offs?
- Where are the pilot lights?
- Where are the electrical outlets?
- What is their voltage?
- Will circuits be live during fumigation?
- Can you use the outlets to operate your circulating fans?
- Does the building contain any high-priority items that may have to be shipped within a few hours notice?

Outside the Building

- From what materials is the structure built? (Fumigants readily pass through certain materials such as wood.)
- Can you make the structure relatively airtight through sealing?
- Will it be necessary to tarp the entire building?
- If you tarp the structure, can you make a tight ground seal?
- Are there shrubs next to the building?
- Will they be damaged by the fumigant or by your digging to create a ground seal?
- Can you move these plants if necessary?
- How far is it to the nearest building?
- Does that building have air conditioning?
- Does it have air intakes that might draw the fumigant inside, particularly during aeration?

- How will you aerate the structure after fumigation?
- Are there exhaust fans?
- Where are the fan switches?
- Are there windows and doors that you can open for cross ventilation?
- Is the structure to be fumigated located where your operations may attract bystanders? If so, consider asking police to assist your own guards.
- Where is the nearest medical facility?
- Do you have the telephone number of a poison control center?

Once you are confident that you have covered everything, prepare a list of things to do. Make a second list of materials that you will need. See Unit 6 and Appendix A for sample checklists. Do not rely on your memory. With the checklists in hand, ask yourself one final question.

- What have I overlooked?

Types of Sealed Structures

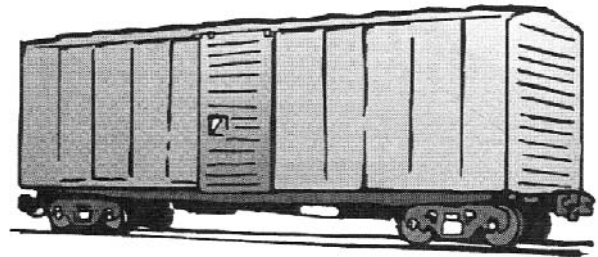
Wheeled Carriers

Fumigating items inside wheeled carriers such as boxcars and truck trailers is one of the most common types of commodity fumigation. This method saves time and labor. It avoids extra loading and unloading. It controls the pests in the commodity. It ensures that live pests do not remain after unloading. In addition, fumigation of incoming loads prevents the introduction of pests into uninfested areas.

Boxcars and truck trailers have a high rate of insect infestation. They are also ideal vaults for fumigation. Wheeled carriers must be airtight for fumigation to be successful. Fumigants must stay inside the truck or boxcar long enough to control the pests. Well-built structures can be made relatively airtight by sealing them with fumigation tape or liquid adhesive. Structures with large holes or cracks, or structures made of permeable materials such as wood, may need to be tarped. See “Tarpaulin Fumigation” later in this unit to learn about this type of fumigation.

First, inspect and clean the boxcar or truck trailer while it is empty. Look for small holes or cracks that may allow fumigant to escape. Use fumigation tape, liquid adhesive, or caulking to

seal any gaps. Then seal the door that will not be used for loading. Secure a pre-cut, two or four mil polyethylene sheet over the entire door. Compute the volume of the container to determine the dosage. See Appendix B for information on how to calculate volume.



Boxcar

Next, apply the fumigant. Every product is different. Read the label information to determine how to best apply the product you are using.

Next, cover the last door with polyethylene before closing and sealing it with fumigation tape. As required by law, place a warning sign on each door. On both signs write the date and time of fumigation and the name, address, and telephone number of the applicator. Return any unused fumigant to a locked chemical storage area. Dispose of empty fumigant containers according to the directions in the label information. See Units 6 and 8 for more information on the safe use and disposal of fumigants.

NOTE: It is illegal to transport goods over public roads or highways if those goods are undergoing fumigation or have not completely aerated.

Ship Fumigation

Like fumigation of wheeled carriers, ship fumigation treats goods while they are still on board. This avoids extra loading and unloading. It controls the pests in the commodity and ensures that live pests do not remain after unloading. Fumigation of incoming loads also prevents the introduction of pests into uninfested areas. This is particularly important for products arriving from overseas.

Ship fumigation involves many people. Close cooperation with the responsible ship officer, ship agent, USDA, and Coast Guard inspector (if involved) is essential. You may also need to notify the Port Authority and the local fire and police departments.

Shipboard fumigation is highly specialized. The problems encountered and techniques used in ship fumigation are unique. In many cases, you may want to hire a company that specializes in ship fumigation.

Tarpaulin Fumigation

Tarpaulin fumigation treats single items or entire structures. It works by placing a semipermeable material over an infested item or structure, sealing the edges, and then releasing fumigant beneath the tarp.

Advantages of Tarpaulin Fumigation

You can use tarpaulin fumigation to treat a variety of items. It is particularly useful when only single pallets or groups of commodities are infested. Instead of fumigating an entire warehouse full of goods, tarpaulin fumigation allows you to treat only those items that are infested. This saves time and money. In addition, you can tarp and treat individual items or groups of items where they stand, if it is permitted by the label information. This also saves time and money. Because many sections of tarp can be clamped together, there is no limit to the size of the stack or structure that can be covered.

Disadvantages of Tarpaulin Fumigation

The biggest problem with tarpaulin fumigation (of structures or outdoor treatments) is the weather. Weather conditions can delay fumigation. If there has been a recent heavy rain, the roof of a structure may be too slippery for safe work. Structures with wood roofs or concrete blockhouses can sorb enough moisture to cause problems after the tarps are placed on the house. In addition, if the temperature is below the labeled minimum, you must delay treatment until the structure is warm enough to comply with the label information.

Types of Tarpaulins

An important aspect of tarpaulin fumigation is the type of “tarp” you select. Some tarps are

specially made for fumigation, such as impregnated nylon. Others are more generic but equally effective like sheet polyethylene. Each type has its pros and cons.

Impregnated nylon tarps are strong. They resist ripping and are reusable. In addition, you can clamp or tape together many sections of impregnated nylon tarps. This allows you to cover structures and commodities of almost any size. Unfortunately, impregnated nylon tarps are expensive. They are also heavier, which makes them more difficult to use.

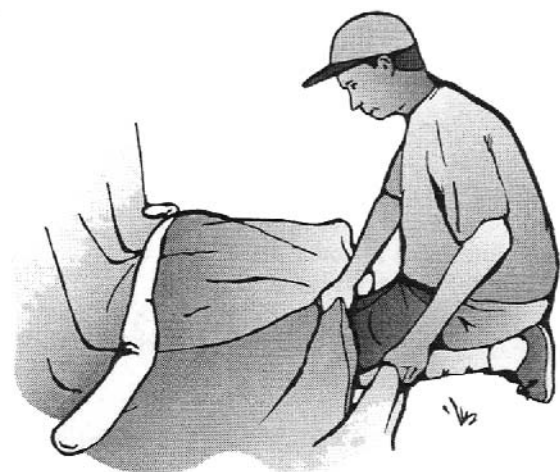
Polyethylene sheeting comes in a variety of thicknesses – some are reusable and some are not. Thinner sheets (three mil or less) can be used once and are for indoor treatments only. Outdoors you can use four and six mil polyethylene. Six mil sheets can be reused if they are not worn or ripped excessively. To join together sections of polyethylene, use fumigation tape instead of clamps. Thinner sheets of polyethylene are often preferred to nylon tarps because they are less expensive and disposable. However, because they can tear easily, you must use them with care.

Ground Seals

In addition to proper tarp selection, also consider the type of ground seal you will need. If they are smooth, concrete and asphalt surfaces provide the base for a good ground seal. Wood surfaces do not. With wood, and frequently with soil surfaces, it is necessary to place a section of the tarp beneath the item to be fumigated as well as over the top of the item. Otherwise, gas may escape through the wood or soil.

There are several ways to obtain a good ground seal. First, cover the infested item allowing at least 18 inches of tarp to skirt out from the base. Then, lay loose sand, sand snakes, or water snakes to hold the skirt to the ground surface. Snakes are tubes of cloth or plastic filled about three-fourths full with sand, gravel, or water. All types of snakes should overlap each other about 1 1/2 feet.

Sometimes you can attach adhesive fumigation tape directly to the floor. However,



you will still need sand, gravel, or water snakes to prevent the tarp from blowing off during treatment. Occasionally, you may need to treat an item that is too close to a wall to obtain a good ground seal. In this case, move the item and seal the tarp properly to the floor.

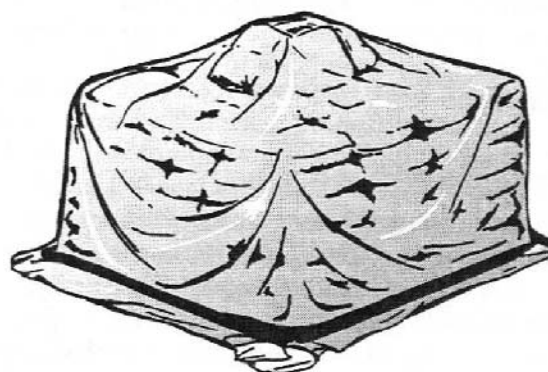
Tarping Individual Items

Frequently, only single pallets or groups of commodities need treatment. With tarpaulin fumigation, you can cover and fumigate these items in place or at a nearby location.

Basic Procedures

First, erect tarp supports one to two feet higher than the stacked commodity or item. This will create an air dome. An air dome assures adequate gas circulation during fumigation. Secure gas introduction tubes above the commodity or item. Place polyethylene sheeting under the outlet of the gas introduction tube. This will protect the commodity from any liquid fumigant that may accumulate during discharge. Next, pad all corners to prevent the tarp from tearing. The lighter the tarp material, the greater the chance for rips.

If the stack is large, use nonsparking fans to assure adequate gas circulation. Turn on the fans for 30 minutes to one hour after introducing the fumigant. Run tubing from various positions in the stack (usually, one located high in the stack, one at an intermediate location, and one at a low location) to the point where you will sample gas concentrations. Then place and seal the tarp to the floor. Determine the volume of



the space beneath the tarp to calculate the amount of fumigant to use. See Appendix B for information on how to calculate volume.

NOTE: The air dome, tubing, and fans are not necessary or recommended when using aluminum phosphide.

Indoors

Tarpaulin fumigation is easiest and most effective indoors. Protection from wind and rain is critical. However, most indoor treatments require you to evacuate the entire building. Some fumigants may allow work to continue in other parts of the building, as long as the treatment area remains clear. Of course, you must post warning signs and monitor the area regularly.

If the item you wish to treat is in an unsuitable indoor site, it may be better to move the commodity to another indoor location than to fumigate outdoors. Make this decision when you first inspect the structure. For ease of movement, place all commodities on pallets for fumigation.

Outdoors

The same procedures outlined for indoor treatments apply to fumigation outdoors. The difference is that outdoor tarps must be stronger and more durable. If you use polyethylene, it must be at least four mils thick. Six mil sheets are better. The color of the tarp also makes a difference. Clear polyethylene tends to become brittle from ultraviolet rays of the sun. In some cases, rays of sunlight can concentrate through

water drops on clear tarps and cause fires. If you plan to keep the polyethylene tarp in place after fumigation is complete, or if you will reuse it, consider black polyethylene. It is more resistant to sunlight, and it is not transparent. However, there are some dangers with black tarps. For example, if the tarp spans several stacks, it may conceal gaps between the stacks or other voids. Persons working on top of the tarp must be careful not to fall through. Once fumigation begins, a fall could be fatal.

There are several challenges with outdoor fumigation. First, it is more difficult to obtain a good ground seal outdoors. Sand and water snakes are often less effective because the ground is usually porous and uneven. Instead, place a layer of loose sand on the tarp skirt to obtain a good seal. You will also need to plan for bad weather. If you know it will be stormy, delay fumigation. Place braces over the item(s) (but under the tarp) so that rain will not accumulate in any low spot. Also, place sand snakes or sandbags over the tarp to protect it against wind.

Tarping an Entire Structure

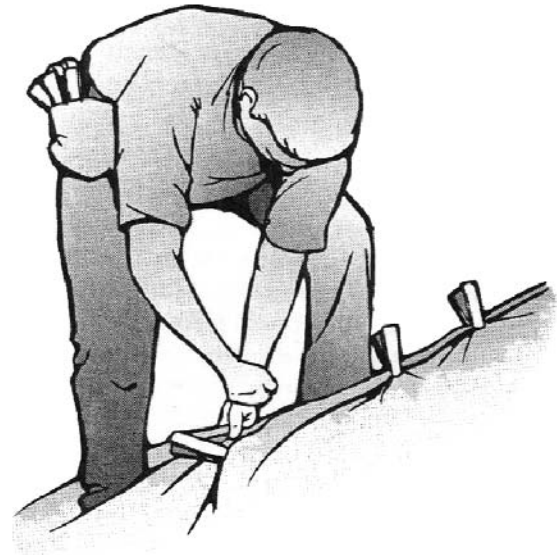
Sometimes, you may need to treat an entire building.

Basic Procedures

When fumigating an entire structure, good preparation is critical. First, remove all items that the fumigant may damage or that the label information requires. Evacuate the building for the entire fumigation and aeration period. Turn off pilot lights, flames, and electrical heating elements. Place tubing to draw air samples from several places within the structure. Use these tubes to administer the fumigant, and test its concentration during the treatment and aeration. It is best to introduce the fumigant at several locations. Place electric fans so that the fumigant will circulate throughout the structure and achieve rapid equilibrium. Local fire authorities may require the use of nonsparking fans.

If landscape plants are too close to the structure to permit a good ground seal, move the plants. Pad all edges of the structure that may puncture or tear the tarp. To be safe, ask all workers to wear shoes with nonskid surfaces.

Slips or falls can be very dangerous during fumigation. All ladders should be strong and braced. Use these to carry tarp sections to the rooftop. If you use impregnated vinyl or nylon tarps, roll together the edges of two tarp sections. Place clamps approximately 8 inches apart (4 inches apart if windy) along the seam. Drop the tarp over the sides of the structure. Complete any additional clamping or taping at this point.



Excessive “billowing” of a tarp can speed the loss of fumigant from a structure. Billowing occurs when air beneath a tarp causes the tarp to bulge outward. Prevent this by keeping the tarp tight against the structure. For example, if the building top is flat, use sand snakes to hold down the tarp. If the roof is peaked, throw weighted ropes over the tarp. Draw the tarp as close to the building as possible. One technique involves a high-capacity electric fan. Place the fan in one doorway and direct it outward. This may create a partial vacuum that will draw the tarp against the structure. Then, you can gather and tape down the excess material at the corners of the structure.

As in any fumigation, the ground seal is very important. The ground should be level and free of vegetation. If the soil is porous or dry, soak the soil around the perimeter of the building with water. This will help prevent fumigant from escaping through the soil. Make sure the tarp skirt is at least 24 inches and weighted down by loose sand, water snakes, or sand snakes. If you use water or sand snakes, double or triple them in windy weather.

Spot (Local) Fumigation

Spot fumigation is the short-term treatment of machinery and small storages with toxic gases. It is used to control pests that infest whole foods and food particles that remain within processing equipment. Spot treatments work by interrupting the life cycles of insect pests. Since one or more stages of the insect (egg, larvae, nymph, adult) may survive, you must repeat spot fumigation regularly to maintain control. Use spot fumigation to control stored product pests in:

- Bins, silos, and holding tanks
- Elevator boots and heads
- Filters
- Conveyors
- Spouting
- Purifiers
- Food processing equipment
- Sifters, rollers, and dusters, and
- Related equipment in mills, food and feed processing plants, breweries, and similar industries

Spot fumigation is most useful where there is an accumulation of static or nonmoving stock. In an industrial setting, the following sites are susceptible:

- In elevator boots behind the feeder rolls on older style roll stands
- On the feeder rolls on newer type rolls
- In purifier conveyors on old-style wooden purifiers
- Pickup converters, screw conveyors, or the air chambers and feeders of the newer type Buhler or Miag purifiers
- The rear side of Draver feeders
- The top of each sifter section
- The inlets of feed finishers
- Directly below the elevator heads in each side of an elevator leg
- The canted 01: sloped area directly beneath the elevator head pulley (in most conventional or bucket-type mills, this area is not accessible for cleaning and is often overlooked during spot treatments)
- Automatic flour and feed scales
- The inlets leading to cyclone dust collectors
- Vertical air trunks, and
- Horizontal air trunks

Advantages of Spot Fumigation

Insect infestations are usually not uniform. They concentrate in specific locations within equipment and storage areas. Spot fumigation allows you to treat only those areas where insects exist. This saves time and money, and it puts less fumigant into the environment.

Disadvantages of Spot Fumigation

Spot fumigation is often labor intensive. Without fumiports, you must cut up and insert prepackaged fumigant such as phosphine Prepac into the machinery at several locations. In addition, when treatment is complete, you must retrieve each Prepac or risk contaminating product during future processing. Spot fumigation can also be time consuming. Calculating the volumes of several small locations is cumbersome. Finally, disposal of spot fumigants like phosphine is difficult because you must deactivate the chemical before transporting it off site.

Basic Procedures

Several things can affect the success of spot fumigation. Most important is your understanding of the equipment you treat and the airflow patterns within a warehouse. Always review diagrams of the facility and inspect the machinery. Determine whether you can make the site sufficiently gastight. Next, develop an application plan. Be sure your plan includes:

- The necessary staff and supplies.
- An application route. This route should be quick and efficient. It should also minimize applicator exposure.
- Security provisions during treatment. Post appropriate signage and notify the facility's personnel. Do not allow unauthorized persons to enter the treated area(s) prior to aeration.
- A procedure for sealing the equipment before treatment. Repair machinery, transfer lines, bins, or other equipment before treatment. This may improve the equipment's ability to retain gas.
- Dosage rates and application points.
- Safety provisions. Respiration protection is often required during spot fumigation. Always preplan ways you and other

applicators can reduce your exposure to the fumigant. These methods may include wearing respiratory protection, working near an open window, or using fans or forced ventilation.

- A record or log detailing the procedure. The log should include dates, dosage rates, and application points.
- Recommendations for the permanent installation of fumiports. Place fumiports inside the equipment to eliminate the possibility of contamination.
- A procedure for monitoring fumigant concentrations. Using an approved gas detector, take readings at regular intervals. Note fumigant concentrations during application to be sure fumigant levels get high enough for long enough to kill the pest. Note fumigant concentrations during aeration. Allow reentry only when gas levels are safe.
- A procedure for recovery, deactivation, and disposal of the fumigant when using phosphine. This plan must include emergency monitoring procedures.

Clearly mark all application points, particularly those that may not be visible from the floor level. Also, mark points where ladders are needed to reach overhead areas. Prepare a checklist or chart for each facility. Show the location and number of application points on each floor. As you treat each point, check off the appropriate location on the chart. In this way, you can be sure you did not miss any points before moving to the next floor.

Before treatment, run the machinery to empty the process stream. In mills, turn off the feed and allow the mill to run for 30 to 45 minutes. During this period, use rubber mallets to tap on the spouting, elevator legs, and sifters. This will help to loosen product that is trapped inside. Check outlet channels in the sifters to be sure they are not blocked or choked.

Next, seal the equipment. This will prevent fumigant from escaping. Eliminate drafts inside the equipment by closing off sections that have openings. Then, seal these openings with tape, caulk, tarps, or other materials. Seal dust collector vents with polyethylene sheeting or large plastic bags. Close dust collectors and filter vents to keep the fumigant within the machinery. Thermal currents and drafts can

cause a spot fumigation to fail. Gas may escape before reaching a lethal concentration within the machinery.

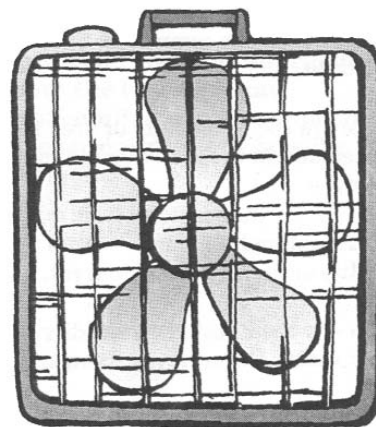
While spot fumigation is less intensive than other methods of fumigation, proper safety is equally important. During application, open windows in rooms that house equipment to allow ventilation. When possible, use a fan or hood to reduce your exposure. Read the label information of each product you use to determine what PPE is required. Approved respiratory protection is required for many spot fumigations. See Units 6 and 7 to learn more about fumigant safety and respiratory equipment.

Aeration After Fumigation

Aeration follows all types of fumigation: vault, tarpaulin, and spot. It is the process by which fumigated air is replaced with fresh air. This can occur in a large warehouse or in an individual piece of equipment. Sometimes aeration involves opening doors and windows. Other times you can use fans and ventilators. Aeration procedures vary according to:

- The fumigant you use
- The area in which you fumigate, and
- The item(s) you treat

Every situation is different.



Proper aeration is important for your safety, the safety of your crew, and the safety of your clients. Read and follow the instructions in the label information for your product exactly.

Factors Affecting Aeration Time

The rate of aeration is affected by several factors. Three of the most important factors are:

- The rate of air exchange
- Air temperature, and
- Sorption and desorption

Rate of Air Exchange

The rate of air exchange within a treated area is the most important factor affecting aeration. The faster air flows through a structure, the faster aeration can occur. Exchange rates are proportional to wind speed and the size and layout of the fumigated area. In atmospheric chambers, an exchange rate of one “air change” per minute is desirable. An air change occurs when 100 percent of the air in a given space is replaced by fresh air. Nonsparking fans are useful for this purpose. They also help to stir up the air in “pockets” or “dead spaces.”

Areas loaded with commodities aerate much slower than empty areas.

Temperature

Temperature can also affect the speed of aeration. As temperature increases, the rate of aeration increases. This is because higher temperatures increase the rates of diffusion and desorption of fumigants. For example, when you aerate areas during colder months, you may use cold outside air. These lower air temperatures will slow desorption. The rate of diffusion will also decrease. Longer aeration time will be needed. For commodity fumigation, it may be necessary to close the area and heat it to 76°F (24°C) (the optimal aeration temperature for most fumigants). Then repeat the aeration process to adequately remove the fumigant.

Sorption and Desorption

As you learned in Unit 3, sorbed fumigant is not available to control pests. It is adsorbed and/or absorbed by materials in the treated area. Still, you must remove it during the aeration process. Some commodities are more sorptive than others are. Some fumigants are

more subject to sorption than others are. The greater the sorptive capacity of the fumigant and the item fumigated, the longer the desorption process and the greater the aeration time needed.

To determine how sorptive a fumigant is, read the label information. Then follow these two rules of thumb:

1. Generally, the lower the boiling point of a fumigant, the lower the sorption rate and the more rapid the aeration.
2. The greater the surface area of the items being fumigated, the greater the sorption rate and the longer the aeration period needed for desorption. For example, the surface area of grain is high. (A load of grain consists of many small pieces, each with a surface area. Together these add up.) Because of its high surface area, the desorption rate of grain is slow. It is usually advisable to hold grain an additional 24 hours after the satisfactory aeration period. Other highly sorptive materials include flour, meals, and burlap bags (used to hold many stored products). You will need to increase aeration times when treating these materials as well.

Aeration Procedures

Procedures for aeration vary with the fumigant, the area, and the items fumigated. Read the label information for aeration procedures specific to each product that you use. Follow the instructions exactly.

Aeration of Fumigation Chambers

The way you aerate a fumigation chamber depends on whether the chamber is indoors or outdoors. When a fumigation chamber is within a building where people are likely to be present, install intake and exhaust pipes for safe aeration. These pipes lead to the outside. The intake pipe will draw fresh air in while blowing fumigant-treated air outside. Turn on air circulation equipment in the chamber to exchange air between the chamber and the outside.

When a fumigation chamber is outside, aeration is straightforward. Simply open the door slightly and turn on the blower. Be sure to prop open the door so it does not accidentally close. If the door closes, the partial vacuum created by the blower may damage the chamber. Channel the air from the blower to the outside of the chamber.

Do not stand near the chamber door or exhaust when the blower is on. Check gas levels regularly during aeration. Be sure to use a gas detector that is approved for the product you are using. If fumigant levels are too high, stay out of or away from the treated area unless you are wearing the appropriate respiratory protection.

After aeration, collect all empty fumigant containers, packaging materials, and solid residues (such as those from metal phosphide fumigants). Transport these materials to an appropriate site for further deactivation and disposal. Follow the disposal instructions outlined in the label information.

Aerating Buildings

After fumigation, aerate buildings by opening doors and windows and turning on ventilators. First, open ground floor windows and doors from the outside. Allow buildings to air out for a minimum of 30 to 60 minutes before entry. Then open other windows and doors. Check detectors to be sure fumigant levels are safe. Read the label information for other aeration requirements.

At the beginning of the aeration procedure, only enter the building for short periods. Always enter in pairs and wear approved respirators. Once inside, open doors and windows on the first floor first. Target windows that provide thorough cross ventilation. Then return to the outside. If ground floor ventilation occurred before entry, work upward floor by floor. Open windows. Turn on nonsparking fans and allow them to run until aeration is complete. Take concentration readings to determine if exposures are within allowable limits.

After the building has been partially aerated, reenter with a partner wearing approved respirators. Open as many of the remaining windows as needed to complete aeration.

When the building has completely aerated, begin testing gas levels. Using approved detectors, test closets, appliances, equipment, stacked commodities, and other items to make sure that no gas is remaining. While wearing a respirator, beat mattresses and upholstered furniture to release any gas present. Aerating the building and its contents is extremely important. Follow the directions in the label information closely. The first rule of reentry is “check it first.”

Tarpaulin Aeration

Safe tarpaulin aeration can be trickier than it seems. When aerating loads under tarps on still, humid days, follow these steps. Place a blower on one end of the load. Make an opening on the opposite end by lifting the tarp. Then turn on the blower and discharge the fumigant. If a breeze or steady cross ventilation is available, a blower may not be necessary. If you choose not to use a blower or cross ventilation, aerate the item or area by lifting the tarp at the corners. Then, slowly raise the sides until the tarp is completely removed.

If aeration occurs outside and there is a breeze, pay attention to which way the breeze is blowing. Always lift the end or side of the tarp opposite the direction of wind movement first. Then lift the portion of the tarp on the windward side. If the first opening is on the windward side, fumigant vapors will be forced backward and may endanger workers.



Tarpaulin Aeration

Wear a respirator or gas mask during all phases of tarpaulin aeration. Evacuate occupants, other than fumigation workers, before aerating tarped items.

Aeration After Spot Fumigation

Initiate aeration after spot fumigation by turning on ventilators and opening doors and windows in the treated area(s). Remove covers from bins, vessels, and other equipment. Turn on dust collector fans.

Aeration after spot fumigation is generally complete in less than one hour. Wear respiratory protection during aeration as directed by the label information. Always check gas levels with an approved gas detector before reentry.

For fumigation and aeration to be safe and effective, you must select the appropriate fumigation method and follow the procedures outlined in this unit. You should also know how to select and use the equipment described in the next unit.

Test Your Knowledge

Q. What is the purpose of fumigation?

- A. To achieve and contain an adequate concentration of the gas for the time needed to kill pests.

Q. Name the three main types of fumigation.

- A. 1. Vault fumigation
2. Tarpaulin fumigation
3. Spot (or local) fumigation

Q. Describe two types of vaults used for fumigation.

- A. 1. Vacuum chamber – A large steel structure in which fumigation is conducted at a reduced air pressure.
2. Atmospheric chamber – A small, isolated building built or modified for fumigation at normal air pressure.

Q. Give three examples of specialized vault fumigation.

- A. 1. Ship fumigation
2. Truck and boxcar fumigation
3. Tape and seal fumigation

Q. What is the biggest problem with tape and seal fumigations?

- A. They are notoriously leaky.

Q. True or False: Impregnated nylon tarps can be used again and again due to their strength.

- A. True.

Q. What extra step do you need to take when fumigating on a soil or wood surface and sealing tarps? Why?

- A. Spread a section of the tarp beneath the material to be fumigated. Otherwise, fumigant can leak through the soil or wood.

Q. Describe how you would achieve an adequate seal when performing tarpaulin fumigation on a pallet of goods.

- A. Cover the item. Allow at least 18 inches of the tarp to skirt out from the base of the stack. Place overlapping sand or water snakes on the tarp around the perimeter of the stack. Try to work on a level surface.

Q. How is outdoor tarpaulin fumigation different from indoor tarpaulin fumigation?

- A. When fumigating outdoors, the tarp must be of stronger material. Obtaining a good ground seal is more challenging. You must protect against unexpected bad weather outdoors. In general, indoor tarpaulin fumigation is preferred.

Q. Spot fumigation is primarily used to treat _____.

- A. Infested processing machinery and equipment

Q. Name several things needed for a spot fumigation application plan.

- A. 1. The necessary staff and supplies.
2. An application route.
3. Security provisions during treatment (ex., warning signs and security personnel).
4. A procedure for sealing the equipment before treatment.
5. Dosage rates and application points.
6. Safety provisions (ex., PPE and ventilation equipment).

7. Logs for recording dosage and points of application.
8. Recommendations for the permanent installation of fumiports.
9. A procedure for monitoring fumigant concentrations during fumigation and aeration.
10. A procedure for recovery, deactivation, and disposal of the fumigant.

Q. What are three important variables impacting fumigant aeration?

- A. 1. Rate of air exchange
2. Temperature
3. The rate of desorption

Q. Under what conditions can you enter a partially aerated structure?

- A. If you are wearing a respirator that is approved for the fumigant you are using and if you are accompanied by at least one other person.

Q. Describe how to aerate a tarped stack of commodities.

- A. Place a blower on one end of the load. Make an opening on the opposite end by lifting the tarp. Then turn on the blower and discharge the fumigant. If a breeze or steady cross ventilation is available, a blower may not be necessary. If you choose not to use a blower or cross ventilation, aerate the item or area by lifting the tarp at the corners. Then, slowly raise the sides until the tarp is completely removed.