

# **FUMIGATION**

*for*

# **INSECT CONTROL**

**Departments of  
Entomology and  
Agricultural Engineering**

**Federal Cooperative Extension Service  
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# Fumigation *for* Insect Control

DEPARTMENTS OF ENTOMOLOGY AND AGRICULTURAL ENGINEERING  
OREGON STATE COLLEGE

**D**ESTRUCTIVE GASES are one of the most effective means of combating insects which attack grain, mill products, flour, cereals, and seeds. Insects that may be controlled by fumigation are the bean weevil, the pea weevil, the vetch weevil, the meal and flour moths, the granary beetles, and other insects that feed upon and multiply in stored grain, mill products and seeds.

To be effective, fumigation must be done carefully and properly. It is absolutely necessary that the rooms or containers to be fumigated be made as nearly gas-tight as possible. Fumigation cannot be accomplished successfully if the gas can escape rapidly. Small amounts of material may be placed in tight cans, jars, or boxes for treatment. Airtight bins or rooms of adequate size must be provided for larger quantities.

The quantity of fumigant used is based upon the cubic contents of the space to be fumigated. The dimensions of the room or container should be taken and the cubic contents computed as accurately as possible. The materials to be used for fumigation may be purchased from dealers handling insecticides.

In combating insects infesting stored products, five types of fumigation are in common use: (1) vault fumigation, (2) railway freight car fumigation, (3) the general or large scale fumigation of warehouses and mills, (4) bin fumigation, and (5) vacuum fumigation.

## Vault Fumigation

Vault fumigation is the term applied to fumigation in a room especially constructed for that purpose.

### Plans for building a fumigation vault

A fumigation room for the fumigation of sacked grain will be more satisfactory if constructed as a separate building rather than built inside of another building. The separate building can be ventilated more easily and there is no danger of the fumigating gas spreading through another building and causing hazardous conditions for the operators.

The building must be strong enough to hold sacked grain stacked at least five sacks high and the room must be tight enough to hold

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This bulletin is revised from and is to supersede Extension Circular 352, an earlier publication on the same subject.

a volatile gas. Since the grain ordinarily will be trucked from the field to the fumigator it is best to plan for convenience with respect to loading and unloading from a truck.

### Size of fumigator required

Vetch and peas probably will be handled in regular grain sacks on the farm. These sacks require a floor space 18 x 36 inches in order to provide a few inches of alley between the rows of sacks. Ordinarily the sacks will be moved on regular warehouse grain trucks and the sacks piled five high. The capacity of various sizes of buildings in sacks of grain when piled five high and in total volume with eight-foot ceiling is as follows:

<i>Size of building</i>	<i>Number of sacks</i>	<i>Total volume in cubic feet</i>
8 x 12 feet .....	90	768
8 x 16 feet .....	115	1,024
12 x 12 feet .....	140	1,152
12 x 16 feet .....	190	1,536

Since the interior of the fumigator is to be lined with 4 x 8 foot sheets of plywood, the exterior dimensions of the building should be worked out carefully so that the inside dimensions will permit installation of the 4 x 8 foot sheets on walls, floor and ceiling with a minimum of cutting and without spaces at the joints.

### Foundation and floor construction

The drawing of foundation detail (Figure 1) shows the recommended size of concrete footings for the posts. These footings should be 18 x 18 inches and 8 inches thick. The bottom of the footings should be approximately 14 inches below the ground level. In order to keep the wooden posts above the ground, a 6- x 8-inch concrete pier should be placed on top of each footing extending at least 6 inches above ground level. These will then support 6- x 8-inch wood posts which should be spaced approximately 4 feet, center to center. For an 8-foot fumigation house, the total distance between the outside edges of the 6- x 8-inch posts and girders should be 8 feet 9 $\frac{1}{4}$  inches. This will leave the distance between the interior plywood walls exactly 8 feet, the size of standard sheets of plywood to be used under the floor and on the inside of the end walls. Diagonal bracing should be installed between the 6- x 8-inch foundation posts in both directions.

Girders or stringers running lengthwise of the building should be 6 x 8 inches and laid in a flat position. They are laid in a flat position in order to provide sufficient width to support the ends of the floor planks. This particular construction is necessary to make

the room gas-tight. The girders should be spaced approximately 4 feet, center to center.

Instead of using floor joists, a less expensive and more substantial construction can be made by the use of 2-inch tongue and groove planking (car decking) without joists. In order to make the floor gas-tight it is recommended that  $\frac{1}{4}$ -inch plywood be installed over the girders before the floor is laid. Exposed joints between the plywood sheets should be covered with battens on the under side. Particular attention should be given to the joints between the floor and the sill plates of the end walls, which also should be well battened. The plywood should be nailed to the 2-inch flooring from the under side to prevent sagging. The flooring should be securely surface nailed at the ends to the outside girders. This is necessary to prevent the outside walls from spreading. The footings and girders may be extended about 6 feet on the door end so as to provide a platform for loading.

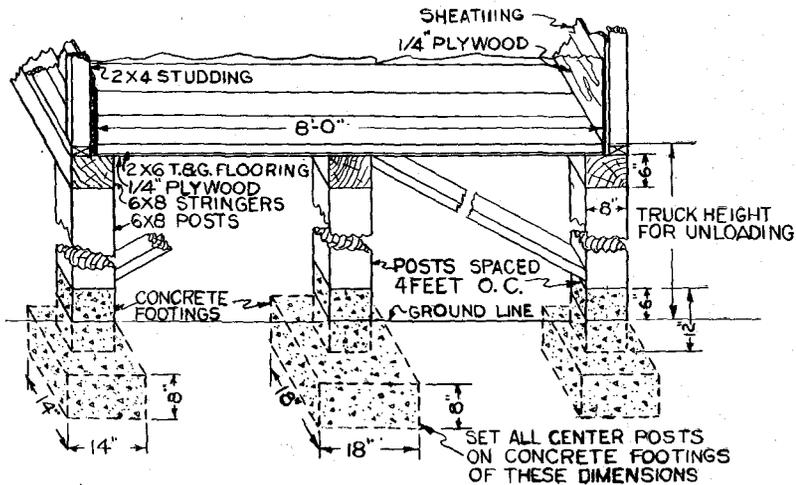


Figure 1. Foundation detail. The bottom of the footings should be about 14 inches below ground level.

### Wall construction

The 2- x 4-inch sill plate which carries the 2- x 4-inch wall studding (Figure 2) should be nailed directly to the 6- x 8-inch girders and not on top of the floor. This is important in order to make the room gas-tight. It is recommended that the inside of the studding be covered first with some kind of  $\frac{3}{4}$ -inch material such as shiplap which is to be covered with  $\frac{1}{4}$ -inch plywood. Three-quarter

inch plywood has sufficient rigidity to serve as an inside wall finish without backing material. The plywood on the walls should extend down to the 6- x 8-inch girders. The floor should not be laid until the walls have been finished in order to make the best gas-tight construction.

The studsing should be 16 inches or 2 feet on centers and the 4-foot sheets of plywood should be joined over a stud. Figure 4 indicates clearly how to place the studsing for the best corner construction in order to keep the building gas-tight.

Battens covering the plywood joints on the walls should be installed after the floor is laid. If a heavy paint is applied over the

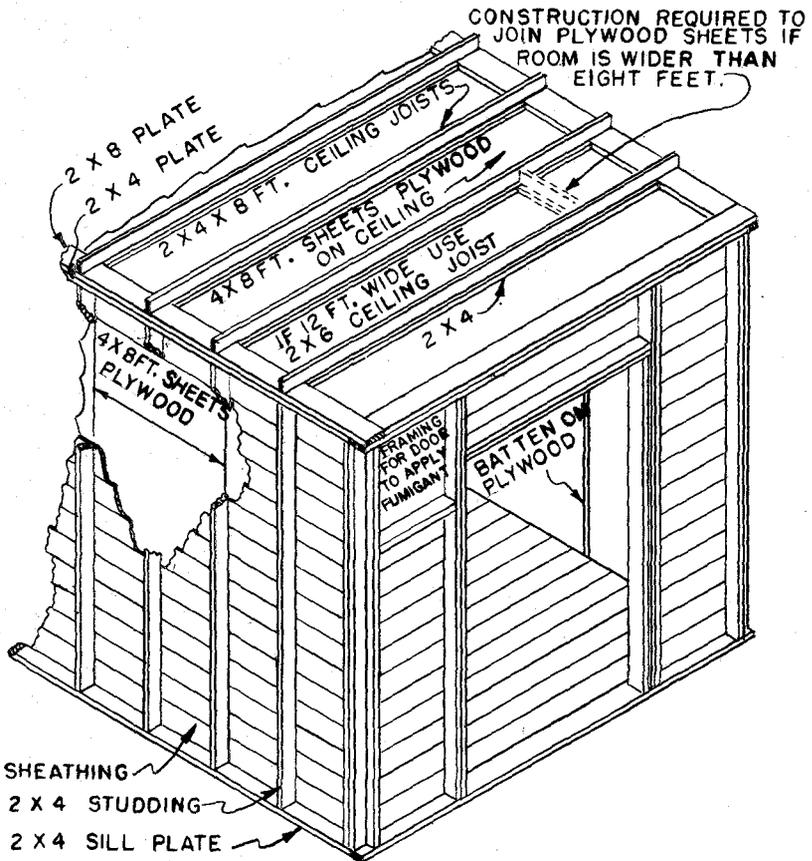


Figure 2. Construction details for the fumigation chamber. Outside dimensions should be planned to allow a minimum of cutting on plywood sheets used as interior lining.



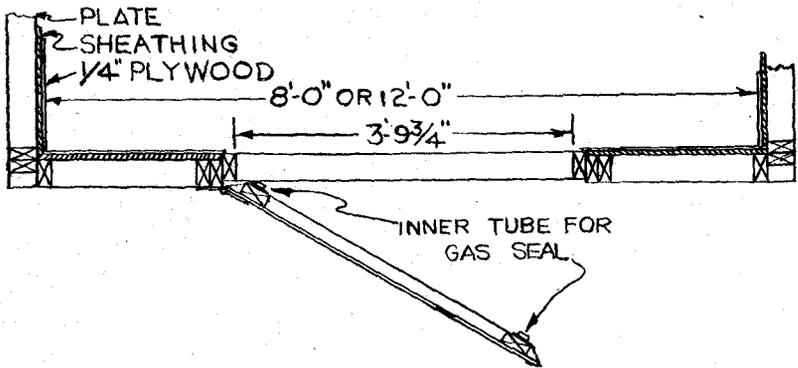


Figure 5. Construction details of door (plan view). Rubber stretches around jamb when door is closed to form gas-tight seal at top and both sides of door.

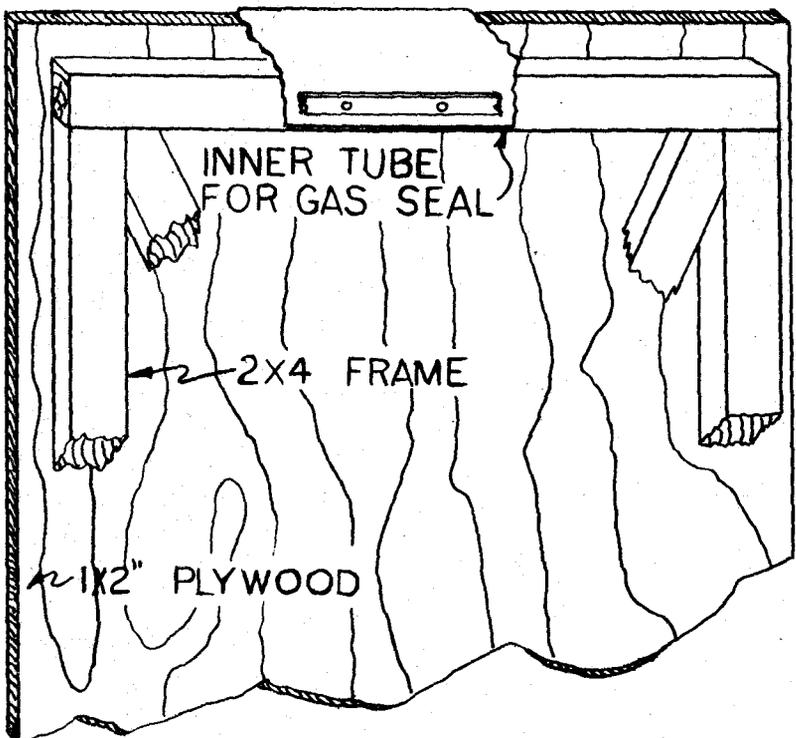


Figure 6. Construction details, inside view.

around the 2- x 4-inch door jamb, making an airtight seal (Figures 5 and 6). It is desirable that the inner tube be vulcanized into one continuous piece long enough to extend around the two sides and top of the door. Special care should be used at the lower corners so that the fumigating gas cannot get through at these points. In order to make the door gas-tight at the bottom the 2- x 4-inch frame on the bottom of the door should be beveled as shown in the door detail (Figure 4). A wedge is made by diagonally ripping a 2 x 4 as shown also in Figure 4 and covering this wedge with inner tube rubber stretched tight over the wedge and nailed on the back. This wedge should be pushed under the door after it is closed, to completely seal the gas at the door. A refrigerator-type fastener should be used to hold the door shut.

### **Opening to apply fumigant**

A small door should be installed high up, at one side of the entrance door or in the opposite side of the room, through which the fumigant can be introduced (Figure 2). A door approximately 2 feet square should be adequate. This opening must be made gas-tight by adequate weather stripping.

### **Ventilation**

The design of a fumigator must provide adequate facilities to clear out the fumigating gas from the room before unloading. If the fumigator is inside another building it will require a special ventilating fan. Most fumigating gases are heavier than air and therefore the ventilation outlets should be near the floor.

If a special building is used, two ventilating holes 2 feet wide by 1 foot high should be provided at the floor level in the end opposite the door in line with the alleys between the rows of sacks. These ventilators should be guarded on the inside by 2 x 6's nailed edge-wise against the wall and extending vertically as high as the sacks are piled. Slats should be nailed to the edges of the 2 x 6's so that sacks cannot cover the openings. These ventilator holes must be provided with tight fitting doors that can be opened from the outside, with fasteners which will hold them tightly against weather stripping when in a closed position.

## **Fumigation of Railway Freight Cars**

Fumigation of railway freight cars is suggested only when cars can be tightly sealed. Refrigeration cars and steel freight cars with matched groove flooring and plywood sides usually can be made gas-tight. Special care must be taken to seal the drain vents with

corks and gummed paper. All door edges are covered with strips of heavy gummed wrapping paper or soft wrapping paper coated with axle grease. One door is sealed on the inside and the second door on the outside. The nozzle of the applicator is introduced through the last door before sealing, and the fumigant sprayed toward each end, thus making it unnecessary to enter the car. Gas masks must be worn and should not be removed until well away from the car after sealing the door. The car should be located for fumigation so that workers will not be inconvenienced by escaping gas while sealed or during the aeration period. Much greater quantities of materials are required for fumigation in freight cars than in vaults. Vault fumigation is recommended wherever possible because of its gas-tight construction and greater economy of fumigant.

### **Warehouse Fumigation**

Warehouses, and other large buildings used for the storage of grain, foodstuffs, and seeds are fumigated with any of the heavier-than-air gases, such as methyl bromide, chloropicrin, or ethylene dichloride—carbon tetrachloride mixture. The fumigant is usually sprinkled evenly over the surface of the contents of the bin or over empty sacks spread over the contents. The bin should then be covered as tightly as possible. As the fumigant evaporates, the vapor (being heavier than air) gradually penetrates the material from top to bottom.

The quantity of fumigant needed will depend upon the tightness of construction of the bin or warehouse. Bins are seldom as tight as properly constructed fumigation vaults, hence larger dosages (one-half to several pounds per 1,000 cubic feet) are necessary. Fumigation within loosely constructed wooden buildings should not be undertaken if complete kill is required, as in pea weevil control.

### **Fumigation of Grain Bins on the Farm**

Farm-stored grains frequently become infested with insects. The best method for the elimination of insects in stored grains is the prompt use of a fumigant.

Stored grains can best be protected from insect attack by certain preventive measures taken before the grain is stored. In addition to cleaning up and the use of residual spraying, many farmers make it a regular practice to fumigate their grain each fall.

Each farm storage structure is a particular problem. The construction of farm storage elevators is so varied that it is not possible to give a recommendation that will work equally well for all.

In general, the safest and easiest used fumigants and the dosage for each is as follows:

DOSAGES OF WHEAT FUMIGANTS FOR USE IN CRIB-TYPE WOODEN FARM ELEVATORS.

(Rate per 1,000 bushels)\*

Fumigant	80° F. or above	70° to 80° F.	Below 70° F.
	<i>Gallons</i>	<i>Gallons</i>	<i>Gallons</i>
Carbon bisulfide-carbon tetrachloride (20-80) .....	4	5	6
Carbon bisulfide-carbon tetrachloride-sulfur dioxide (20-78-2) .....	4	5	6
Ethylene dichloride-carbon tetrachloride (75-25) ..	8	10	12
Carbon tetrachloride-carbon bisulfide-ethylene dibromide (76-19-5) .....	4	5	6
Carbon tetrachloride-trichloroethylene-benzene-sulfur dioxide (75-10-12-3) .....	4	5	6
Carbon tetrachloride-ethylene dichloride-ethylene dibromide (60-35-5) .....	4	5	6

\* Adapted from USDA, BEPQEC-24, June, 1952.

These fumigants are safe from the standpoint of fire hazard. A gas mask, of course, should be used when applying these materials. Observe all precautions listed on the manufacturer's label.

Each farmer should examine his elevator before fumigation in order to make the structure as airtight as possible. All windows and doors should be closed. A canvas placed over the grain after applying the fumigant will assist in the retention of the fumes in the grain. Choose a day for fumigation that is warm and without too much wind.

It is recommended that fumigation be carried out within 6 to 8 weeks after storage begins. If it is not possible to fumigate this early, it should not be carried out any later than the last of October. Grain fumigated later than this has cooled to such an extent that the fumigant fails to volatilize rapidly enough to be effective.

Apply the fumigant evenly over the surface of the grain. To facilitate even distribution of fumigant, the grain surface should be leveled.

Inspect your wheat frequently and fumigate if an infestation is discovered.

## Fumigants

The following fumigants are generally used for vault fumigation. Those listed above are preferred for fumigation of grain bins on the farm.

### **Chloropicrin**

Chloropicrin is a colorless or slightly yellowish liquid a little more than one and a half times as heavy as water. On exposure to air it evaporates slowly forming a vapor that is about five times as heavy as air. The gas is nonexplosive and nonflammable as ordinarily used, is extremely toxic to insects and also to man, and has an extremely irritating effect upon the eyes and respiratory passages of man. This last characteristic insures against the probability of anyone accidentally entering a building filled with gas. A gas mask equipped with a canister especially designed for the purpose must be worn when fumigating with chloropicrin.

Chloropicrin is applied in several ways: (1) sprinkling bottle somewhat similar to a bottle used in sprinkling clothes for ironing; (2) sprinkling can (draw the required quantity of liquid from the cylinder in which it is marketed into a sprinkling can and sprinkle it over the floor or commodity or into the machinery); (3) a compressed air sprayer or double action hand sprayer. For vault or freight car fumigation, the material may be applied from the outside through the roof, door, or wall, using a compression sprayer or double action hand sprayer, closing the opening securely after application. Chloropicrin should not be applied directly on painted or varnished surfaces. To keep the material off painted floors, empty sacks should be spread underfoot.

The dosage for vault fumigation is  $1\frac{1}{2}$  pounds per 1,000 cubic feet of space at a temperature of 70° F. Railway freight cars require from 6 to 10 pounds, depending upon the tightness of the car. The exposure period is 24 hours. For most effective results the air-gas mixture should be circulated throughout the exposure period by means of a fan.

An objectionable feature of chloropicrin is that considerable time is required to ventilate a building after fumigation. Because it does not evaporate rapidly, it clings to fumigated commodities with great tenacity. With an outside vault under ordinary circumstances, natural aeration will make it possible to start removing the sacked seed or grain an hour or two after it is opened. If the contents are withdrawn, the vault will continue to air itself. High temperatures hasten aeration. Inside vaults will require a suction type of exhaust fan for aeration, operating through a vent to the outside.

### **Carbon bisulfide**

Carbon bisulfide alone has been used on the farm and in grain elevators for a number of years but is being largely replaced by newer, nonflammable mixtures. It can be used for the treatment of

seeds intended for planting and foodstuffs, for they are in no way harmed when the gas is properly applied. The vapor is flammable and some insurance policies may contain clauses voiding insurance against fire where carbon bisulfide is used for fumigation. Fire only occurs due to carelessness. *There must, therefore, be no smoking or carrying around of lights while fumigating with carbon bisulfide.* It is unsafe even to have hot steam pipes or to turn on or off an electric fan, light, or thermostat. Electric switches cause sparks sufficient to ignite this gas. Even the heavy striking of a nail with a hammer might throw a spark that would cause an explosion, if the necessary density of vapor is present. For fumigation in a vault or gas-tight room, 10 pounds of carbon bisulfide per 1,000 cubic feet is recommended. For rooms or buildings that cannot be made gas-tight, the dosage ranges up to 20 pounds per 1,000 cubic feet. Best results are obtained if the temperature is 70° F. or above during the period of fumigation.

Carbon bisulfide is heavier than air and tends to settle. The liquid may be placed in shallow pans on top of the material to be fumigated or may be sprayed or splashed over empty burlap sacks laid over the material to be fumigated. Where considerable surface is exposed, it is well to divide the liquid and place in bins at several points so as to obtain a more even distribution of gas. As soon as the liquid has been placed in position, immediately close the room or container. In vault fumigation, the carbon bisulfide may be applied through an opening in the wall or ceiling as previously suggested under chloropicrin. Allow the gas to act for 24 hours. The room may then be opened and permitted to air out.

### **Hydrocyanic acid gas**

Hydrocyanic acid gas is a standard fumigant for the protection of greenhouses, large warehouses, dwelling houses, and so forth, against any kind of insect. It kills quickly and is quite effective in buildings not absolutely gas-tight. *This gas, however, is deadly poisonous and should be used only under the direction of experienced operators.*

### **Methyl bromide**

This fumigant is used for fumigation of grain and seeds, as well as fruits, vegetables, nursery stock, and other materials. It is a liquid which vaporizes into a heavier-than-air gas. Methyl bromide is obtainable in 1-pound cans or in cylinders containing 10, 50, or 150 pounds. It is used with applicators sold by the distributing companies. It is nonflammable and diffuses very rapidly. Methyl bromide can be used effectively only in tightly constructed buildings or vaults,

since it diffuses rapidly from loosely constructed joints and openings. The vapors of methyl bromide, if inhaled, are deadly to human beings as well as insects. The following precautionary measures are recommended by the Division of Industrial Hygiene, National Institute of Health, United States Public Health Service, for the use of methyl bromide as a fumigant:

- ▶ Avoid breathing air containing methyl bromide.
- ▶ On completion of fumigation, provide thorough ventilation for cars, rooms or buildings before entering.
- ▶ When necessary to enter spaces containing methyl bromide, use a gas mask provided with a canister giving protection against organic vapors, or with a positive pressure hose.
- ▶ Avoid spilling of methyl bromide. Get to fresh air immediately in case of spillage. Remove any clothing in contact with skin which has become impregnated with the liquid.
- ▶ Post warning signs notifying that methyl bromide is being used and that the gas is toxic.
- ▶ Containers of methyl bromide should be stored in a cool, well-ventilated place, outside inhabited buildings. Avoid leakage by seeing that valves are tightly closed on cylinders.
- ▶ The presence of dangerous concentrations of methyl bromide can be readily detected by the use of a Halide leak-detector lamp. If the color of the flame of the lamp is deeper than a light green it denotes the presence of unsafe concentrations of the gas.

Methyl bromide is used at the rate of 1 to 2 pounds per 1,000 cubic feet of space. The period of exposure is 15 to 24 hours. One of the advantages of methyl bromide is that it can be used at lower temperatures than most other fumigants, but more effective results are obtained at 70° F.

#### **Ethylene dichloride-carbon tetrachloride mixture**

A mixture consisting of three volumes of ethylene dichloride and one volume of carbon tetrachloride is being manufactured and sold commercially for fumigating clothing, furniture, grains, and seeds. The mixture is nonflammable under normal conditions of use, noninjurious to metals, textiles, seeds, and grain when used in the manner recommended by the manufacturer. It should not be used on foodstuffs with a high fat content because of the disagreeable odor and taste that may result. It may be applied in the same manner as suggested for the other fumigants. Dosage is 15 pounds (approximately 5 quarts) for every 1,000 cubic feet of gas-tight space in which the fumigation is conducted. The exposure period is 24 hours.

**Other fumigants**

A number of other good fumigants or mixtures of fumigants are available on the market under various trade names. The manufacturer's recommendations and precautions appearing on the label should be followed.

**Temperature for Fumigation**

The best temperature for fumigation is 70° F. or warmer. Insect development is slow at temperatures between 60° and 70° F. For this reason stored grain should be fumigated during early fall. When vault fumigation is necessary during cooler weather one of the better materials to use would be methyl bromide due to its low vaporization point. Fumigation at temperatures below 60° F. is likely to be ineffective.

**Gas Masks**

A gas mask should be used when fumigating with any toxic chemical in order that the operator may work with comfort and safety. Care should be exercised in the purchase of gas masks in order to get one that has been approved by the Federal Bureau of Mines, and that the proper type of canister is selected for the gas being used.