METHYL BROMIDE FUMIGATION OF GRAINS SEALED IN TENT

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I. THEORY OF FUMIGATION

1. Definition of Fumigation and Fumigants

When grains are damaged by injurious insects, they are usually sealed in a tent or warehouse where they are treated with a certain poisonous gas until the pests are completely destroyed. Such method of controlling pests by exposing to poisonous gas is called 'Fumigation' and the chemicals used 'Fumigants'. There are a variety of fumigants such as hydrocyanic acid, chloropicrim, hydrogen phosophide, etc. Methyl bromide (hereinafter referred to as MB), among others, is the most commonly used fumigant.

MB boils at 4.5°C and as it is a gaseous body at an ordinary temperature, it is put on the market sealed in a pressure-resistant cylinder (usually of 10 - 25kg capacity) or in a pressure-resistant can (500g content). The MB gas has neither color nor odor and is hardly soluble in water. It is an excellent insecticide, but is highly poisonous to man and animals.

2. Unit of dosage and concentration

Fumigation can be carried out in warehouses, silos or aboard freighters and lighters. As is described here, it may also be performed in a tent set up in a warehouse. In any case, a certain amount of chemicals are required for the complete kill of insects. Furthermore, even if a certain amount of chemicals are used, the effective amount of gas in the air decreases as to the lapse of time because of the absorption and leakage (which will be discussed later). The effective amount of chemiclas contained in the air is called gas concentration and often expressed in terms of 'g/m^3', '%', or 'ppm'.

'g/m^3': The unit g/m^3 is commonly used as an indication of gaseous concentration, in which g denotes the amount in weight of chemicals per one cubic meter of air-tight space. Take, for example, the dosage '$20g/m^3$'. This indicates that 20g of chemicals are contained in a space of $1m^3$. If this unit dosage of $20g/m^3$ is applied to an instance where fumigation is desired to be carried out in a tent of $100m^3$ interior space, the required amount of chemical material will be calculated as follows:

20g x 100 = 2,000g

'%' and 'ppm' : The percentage '%' is used to denote the ratio of pure fumigant gas in the mixture of air and fumigant gas. One per cent (1%) means that the aforementioned ratio is 1/100. The 'ppm' (parts per million) is equivalent to 1/10,000 of '%' and accordingly means that the ratio referred to is 1/1,000,000. Thus, 10,000 times one ppm makes one percent. As the volume of gaseous body varies with temperature, the inter-relation among '%', 'ppm' and 'g/m^3' also varies with temperature accordingly. For instance, 1% of MB indicates $42.4g/m^3$ at 0°C, $39.5g/m^3$ at 20°C and $38.2g/m^3$ at 30°C. The % is seldom used as a unit in fumigation. The 'ppm' is usually used in connection with the toxicity against man and livestocks of residual gas in the air.

3. Susceptibility of stored grain insects to methyl bromide

(1) Insect species and susceptibility

There are a number of species of injurious insects that infest grains and they have different degrees of susceptibility to MB. Rice weevil, *Sitophilus zea-mais* which is commonly found in grains, has comparatively weak resistance to MB. By two hours fumigation at 20°C, LD 95 of the adult of this insect lies at $11g/m^3$. LD 95 is defined as the dosage, where 95% of the treated insects can be killed with the remaining 5% surviving. Table

1 shows a grouping of 18 representative stored grain insects on the basis of their comparative susceptibility to MB. For instance, rust-red flour beetle, also a common stored grain insect, has an almost doubly higher resistance than rice weevil.

Table 1 Grouping in susceptibility of common stored grain insects

Group	Susceptibility	Species of insects
I	Approximately same as rice weevil, Sitophilus zea-mais	*Plodia interpunctella, Callosobruchus chinensis, C.maculatus, Sitophilus granarius, Anagasta kuehniells, Ephestia cautella, Rhizoperlha dominica*
II	Slightly more resistant than Group I	*Achanthoscelides obtectus, Stegobium paniceum, Oryzaephilus surinamensis, Cryptolestes minutus*
III	About twice more resistant than Group I	*Tribolium castaneum, T. confusum, Tenebrio obscurus, T.molitor, Attagenus piceus, Tenebroides mauritanicus*
IV	More resistant than Group III	*Trogoderma granarium*

(2) Stage of insects and susceptibility

Susceptibility of insects to fumigants can also differ with the developmental stage of one particular insect species (egg, larva, pupa and adult). In general, egg and adult stage is the most susceptible, whearas larval stage is slightly more resistant and pupal stage is by far the most resistant to MB. If the resistance of adult or of egg is indicated by 1, those of larva and pupa can be roughly estimated to be 1.5 and 2.0, respectively.

4. Factors affecting fumigation effect

Fumigation effect depends on many different factors. Among them, the most essential and important factors are the dosage of chemicals, time of exposure and temperature. When fumigation is conducted in a tent or a warehouse, the degrees of diffusion, penetration, leakage of gas as well as the sorption of gas to the grains also constitute important factors that will influence the effect of fumigation.

(1) Dosage and time of exposure

Insecticidal effect of fumigation can be naturally heightened by larger dosage of fumigants and longer time of exposure. Various experiments have proved, however, that the effect is nearly proportional to the product of dosage and exposure time. Figure 1 diagramatically shows the relation between the insecticidal effect and the product of dosage and exposure time in MB fumigation. The same effect can be obtained either by the dosage of $20g/m^3$ at 4 hours exposure or by the dosage of $10g/m^3$ at 8 hours exposure.

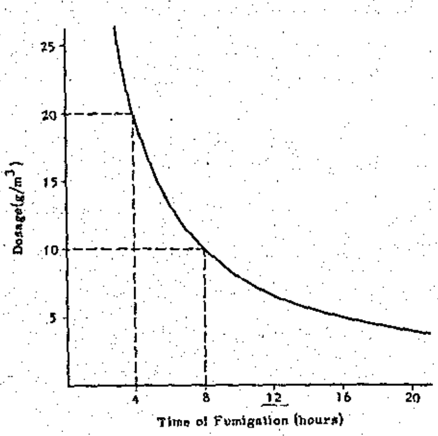

Figure 1 Relation among the effect of fumigation, dosages and time of exposure

(2) Temperature

Within the range of ordinary temperatures, the fumigation effect decreases with the fall of temperatures, though it will again increase below a certain temperature where the insects start to sustain physiological ill effect. The temperature at which the reverse turn of the effect occurs varies with the species of insects. In the temperature range above 10°C, however, it is quite safe to consider that the effect will increase in parallel to the rise of temperature.

(3) Diffusion of Gases

For the satisfactory control of insects in the practical fumigations performed in a warehouse or a tent, a higher dosage of MB than is required in the laboratory condition is usually employed for the reasons mentioned here and in the items (4), (5) and (6).

When fumigants are released from one place or several places in the sealed space, the gas of the fumigant will move freely and tends to distribute uniformly within the limits of the walls enclosing the gas. Such movement of gases to attain the uniform distribution is called 'diffusion'. MB gas is about three times as heavy as air. Thus, it tends to accumulate in layer over the surface of the floor and then gradually diffuses upwards. When MB is released from the floor level it usually takes several to ten hours to reach the uniformity. Therefore, the insects in the upper part of the stacks, will be exposed to MB gas for a comparatively short time and accordingly may have a chance of survival. In order to preclude this, the gas should be released from the top of the grain stacks. The use of electric fan will further promote the diffusion and, consequently, the effect of fumigation. In stacking up grains, it is preferable to pile them in such a way as to allow as much space as possible in between the bags.

(4) Penetration of Gases

Diffusion of gases into the layer of grains is called 'penetration'. Although MB has a relatively high penetrating potential, it takes some time to attain the even distribution in the grain layers. Consequently, within some time after dosing MB, the gas concentration in the hemp bags is lower than that in the space around. The slower, the penetration speed is, the shorter insects inside the bags will be exposed to MB gas. The speed of penetration is also influenced by the size of grains under fumigation. Large grains such as corn and soybean are quickly penetrated, whearas the penetration of milo or wheat is rather slow and, further, the products of fine powder such as wheat flower are very hard to be penetrated. There is no effective means of directly accelerating penetration. Penetration can be indirectly hastened, however, by promoting the speed of the aforementioned diffusion.

(5) Sorption of Gases

Upon contact with the grains, the gas is adsorbed to the surface of the grains. Some portion of the gas may even penetrate into the tissues, dissolve into fats or chemically combine with proteins and other ingredients. This phenomenon is called 'sorption'. Whereas the gases in the air acts on the insects, the gas sorbed to the grains has no insecticidal efficiency. Therefore, the more the volume of the sorbed gas increases, the less will be the gas remaining in the outer space which will eventually reduce the effect of fumigation. The amount of sorption of MB varies with different kinds of grains. Generally speaking, grains of smaller size or those with much oil and proteins sorb a large quantity of gases. Table 2 shows some representative kinds of grains classified by the degrees of sorbing power of MB. Even with the same kind of grains, the amount of sorption will proportionally increase with the amount of the grains in a given space of fumigation.

Table 2 Comparative degrees of MB sorption among various grains

Degree of sorption	Kinds of grains
Low	Rice, wheat, barley, pea, black matpe, copra, cocoa, coffee, Tapioca chip
High	Maize, millet, beans (such as soybean, broad bean), peanut, cotton seed, sesame seed
Very high	Powdered products (such as wheat flour), buck wheat, castor seed, safflower seed

(6) Leakage of Gases

When fumigation takes place in a tent or a warehouse, care must be taken to see whether there is any broken opening in a tent, whether it is set up securely or whether there is any crack on the wall, or chink in the roof. Such openings in either a tent or a warehouse will allow fumigant gases to leak out and thus induce the decrease in gas concentration and impairs the effect of fumigation. The containers in which fumigation is performed should be air-tight. If not, care should always be taken to seal up any such openings before fumigation.

II. INSTRUMENTS FOR TENT FUMIGATION

There are two ways of tent fumigation: one is the way in which a tent is put up in a warehouse like a mosquito net. In this case, the fumigation space is fixed and immovable and the tent used is of rather thick vinyl chloride sheet or of rubber-lined cloth. The other is the way in which a portable tent is used to cover grain stacks. The latter has an advantage in that it can be done at any place whether inside or outside the warehouse. A tent which is rather thin and easy to carry is usually employed in this method as will be described in detail hereafter.

1. Tent

The tent currently being used for fumigation is either of polyethylene or of vinyl chloride. In Japan, the vinyl chloride sheet in the range of 0.1 - 0.2 mm thickness is in general use. Of these, the sheet of 0.15mm thickness has the widest use, because the tent of 0.1 mm thickness is light and easy to carry but easily breakable, while the one of 0.2 mm thickness is durable but heavy and hard to carry. The durable thick sheet is favorably used for the fumigation of lumber that are piled outdoors. The required size of a tent depends on the volume and the shape of the stack of the grains. A tent of 20m square is usually required for the stack of 100 tons piled up in square. A tent of this size (0.15mm thick) weighs about 50kg. This sheet will also suffice for the smaller lots (less than 100 tons). For the fumigation of larger lots (150 - 200 tons), it is a common practise to use two of the aforementioned size of sheet sticked one another. In sticking, the edges of the two sheets must be wiped clean, layed one over the other by about 5cm as is shown in Fig. 3 and stuck by the adhesive sticker (to be called 'sticker' in this paper) of 5cm width. For the reinforsement, additional stickers are stuck at an interval of 1 - 2m at a right angle to the first sticker. In covering grains, care must be taken to see the whole weight of the tent may not press on the joined portion of the sheets. Durability of tent depends a great deal upon handling manner of the workers. In general, it can be used fifteen times unless it is caught on a nail or is trailed on the ground.

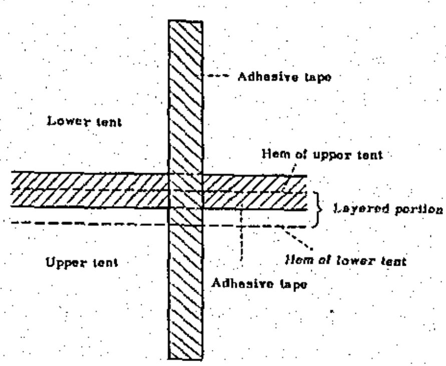

Figure 2 Method of sticking tents

2. Sand Bags

Sand bags are used to press upon the skirts of tents to prevent gas leakage. Hemp bags or vinyl chloride bags of about 0.3mm thickness are generally used for this purpose. Either of the two, especially the latter, is easily torn by mouse bite. Sand bags of 8 - 10cm diameter, and about 60 - 80cm long are hard to manipulate. One hundred to one hundred-fifty sand bags are usually required to fumigate grains of some 100 tons.

3. Opener

As is shown in figure 3, the opener is the device for making a hole at the lower side of 500g can of MB. MB moves of its own accord into the tent through the rubber tube fixed to the hole of the can.

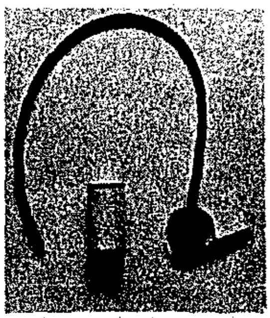

Figure 3 Opener of MB can (center: canned MB)

4. Gas Mask

There are two types of gas mask. One consists of mask and canister that are connected close to each other. The other is the one in which the two parts are separated. The snout-type gas mask is small, light and easy to handle. However, as the absorption capacity is smaller, it is not suitable for use in fumigation. Two kinds of the separate-type mask are available. One is the type which covers all over the face and the other is the one which covers nose and mouth only. Since the latter type of gas mask does not protect the wearer from being splashed in the face with MB, the former type (shown in Figure 4) is safer and is more widely used than the latter. The type of canister to be used in the fumigation differs with the type of the fumigants. The canister for organic gases is to be used for MB. This contains the absorbant consisting mainly of active carbon which absorbs MB gas and allows the passage only of the air. One cartridge of absorbant can stand the maximum use for 30 minutes for 0.5% MB gas ($19.8 g/m^3$ at 20°C) which flows at the speed of 30 l/min. in the relative humidity of 50%. This much flow of the air is nearly equivalent to the breathing capacity of human adults. At the lower concentration of MB gas, the cartridge can be used longer, but, as the concentration increases, its durability becomes shortened. The use of the gas mask must be avoided in the concentration higher than 2% ($79 g/m^3$ at 20°C) because the absorbent is no longer capable of absorbing gas completely, and allows some portion of the gas to pass through. After use, the canister must be disconnected and the air-intake in the lower part of the canister must be plugged tight with stopper so that absorbing capacity of MB may not decrease due to the absorption of moisture or any other gases present in the air.

Figure 4 Gas mask of separate type

5. Measuring Instruments of Gaseous Concentration

Although there is a type of gas measuring apparatus which avails itself of the differentials in thermo-conductivity of gases, the one most commonly used in Japan is an interferometer-type gas analyser (Riken's gas analyser) which is shown in Figure 5. The principle of this analyser is based on the use of the difference in reflection rate of air and MB gas. Two kinds of Riken analyser that are different in sensitivity and measurable concentration range are now being sold in the market. The one called 'Type 18' has the measurable range of 0 - 100g/m^3 and the maximum sensitivity of 0.4g/m^3, while the other called 'Type 21' is usable in the range of 0 - 30g/m^3 with the maximum sensitivity of 0.1g/m^3.

The first step in measuring the gas concentration is to set the most easily detectable stripe of the spectrum on 0 point, and to suck the gas into the analyser by pressing the spray bulb several to more than ten times. When the interference spectrum ceases to move, the distance in movement from 0 point of the selected stripe is read on the scale. As a common practise, the vinyl tubes of 3 - 4mm interior diameter are inserted and distributed into the desired site in the tent or the warehouse. The gas concentration is measured by connecting the analyser with the end of this tube. The necessary frequency of pressing the spray bulb, therefore, depends on the length and the diameter of the vinyl tubes used.

The movement of interference stripe is also induced by the gases other than MB. Grains under fermentation in unfavorable storage condition or grains in active dissimilation process often produce large quantity of carbon dioxide which will also effect the movement of the interference stripe and thus will lead to an unexpected error. Usually, the carbon dioxide of less than 10% concentration can be absorbed and eliminated by the supplemental canister that contains soda lime. In view of the limited absorbing capacity of soda lime, however, frequent change of the supplemented canister is required. The use of so-called 'color lime' is particularly favorable in such circumstance because it turns from its normal blue to reddish color when saturated with carbon dioxide.

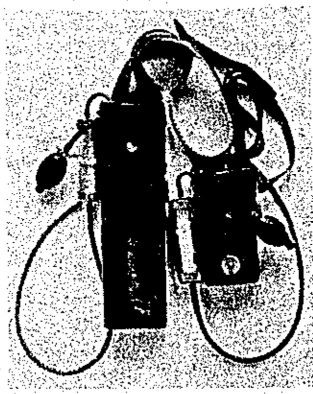

Figure 5 Interferometer-type gas analyser (Riken's gas analyser) (Left: 21 type, Right: 18 type)

6. Gas Leakage Detector

(1) The detector utilizing flame color reaction

When Br relased from the burning of MB comes in contact with red hot copper, there arises volatile copper bromide which, in turn, gives the flame green to blue coloration depending upon the concentration of MB present (Table 3).

Table 3 Relation between flame color and MB concentration

Concentration ppm	Concentration g/m^3	Color of flame
40	0.16	Faint green
60	0.23	Moderate green
100	0.39	Deep green
130	0.51	Green with some bluish tinge
180	0.71	Bluish green
240	0.95	Greenish blue
360	1.42	Deep greenish blue
800	3.16	Deep blue

This is called Beilstein's reaction and is the simplest method of detecting MB. Two types of the gas detector which falls under this category are available. One is so called 'lamp type' and the other is so called 'torch type'. (Figure 6). As fuels, alcohol is used in the former and propane in the latter. Both are handy tools for detecting gas leakage but the latter is more sensitive and appropriate for the leakage detection because it is equipped with a pipe to suck in the sample gas. In the use of these detectors, care must be taken on the following points:

a. Even in the absence of MB gas, the flame tends to be green at the start. Detection should not be made before this greenish tinge fades away by heating the copper coil for a while. Once the flame takes color because of MB gas, it should be left for a proper interval until the color goes out. Only after this, next detection should be made.

b. The size of the flame should be adjusted to allow its top to pass through the copper coil.

c. Care should be taken of the fact that halogen compounds other than MB show a similar reaction.

d. Detector should not be used at such places that are filled with an explosive gas or powdered dusts because of the possible gas or dust explosion.

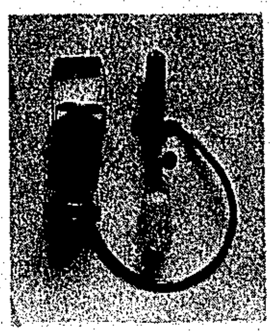

Figure 6 Gas detector of lamp-type (left) and torch-type (right)

(2) Kitagawa System Detector

As is shown in figure 1, this consists of a detector tube and a gas collector of 100ml capacity. The detector tube is filled with a reagent which reacts with MB and turns to brown when the sample gas is introduced from the gas collector. The length of the colored reagent is proportional to the concentration of MB gas. Therefore, the gas concentration will be determined by using the standard table which shows the relation between the length of the coloration and the gas concentration. This detector is sensitive and is suitable for use in the lower concentration range of 0 - 500ppm.

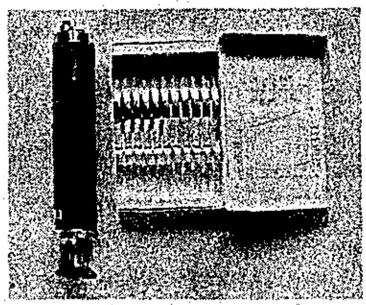

Figure 7 Kitagawa's gas analyser (left: gas collector, right: detector)

III. METHODS OF TENT FUMIGATION

As was previously mentioned, there are two ways of perfoming tent fumigation, the one being a rather inflexible type in which the tent is fixed over the grains like a mosquito net, and the other being a flexible type in which the tent is spread directly over the stack of grains. The fumigation in the latter case will be fully dealt with here.

1. Place for Fumigation

In the tent fumigation, bags of grains that are piled at one place of a warehouse is usually treated. It should never take place where people are working all the time or where they are working nearby. In case there is a crack in the tent or unless the skirts of the tent is carefully sealed all around, there is always a possibility of gas leakage that might lead to the human poisoning. The floor with cracks or with uneven surface should also be avoided.

2. Stacking of Grains

Appropriate size of a grain stack for fumigation is below 100 tons. A pile of 200 or 300 tons can be fumigated, but, as the pile becomes larger, the tent will also become larger and heavier and, therefore, harder to manipulate. Also, in case two or more tents are joined together to cover a big pile, there is a danger of the joined parts loosening. In piling up grain bags, base board of about 10cm x 10cm thick are laid on the floor and the bags are stacked up on them to secure a widest possible space for the passage of air so that MB gas may easily diffuse into the stacks thereby increasing the effect of fumigation. The height of the stack should be less than the maximum of 4 meters. Much higher stacks are harder to work on and may have a chance of collapsing during the fumigation.

3. Insertion of Test Insects and Piping for the Measurement of Gas Concentration

In order to check the effect of fumigation, 20 to 30 reared adults of rust-red flour beetle are put into glass tubes, plugged with cotton and inserted into several gunny bags at the top of the stack remote from the release site of MB. In case of severely infested grains, the effect of fumigation can be assessed by checking the death or survival of the infesting insects.

In measuring gas concentration, one end of the vinyl pipe of 3 to 4 mm diameter is fixed to a desired position within the tent and the other end is taken outside of the tent.

4. Sealing of Grains with Tent

The grain stack is first covered all over by a tent, the hem of which is pulled so that it gathers on the floor by about 2m. Then sand bags are laid on the hem all around in two or three rows in parallel. Three rows are preferable for the prevention of gas leakage. Gas often leaks out from the foot of four corners of a tent. So care must be paid to see whether these corners are securely smoothened under sand bags. After grains are sealed, a close check is desirable for the presence of any cracks in the tent. The crack, if there is any, should be patched up with adhesive tape.

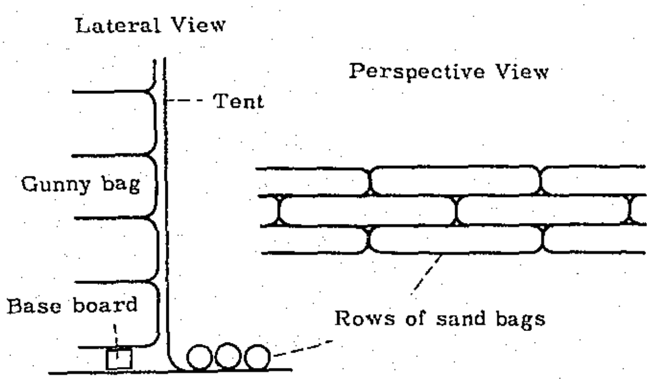

Figure 8 Method of pressing the hems of tent with sand bags

5. Measurement of Fumigation Space and Calculation of Dosage

The volume of the interior fumigation space is calculated by height and width (two sides) of the covered tent. Take, for example, a tent which is 4m high and 7 and 8m wide. The interior space of the tent is calculated as follows:

$4 \times 7 \times 8 = 224m^3$

Next is calculated the amount of MB to be dosed into the tent. Take, for instance, the unit dosage of $25g/m^3$ which will be adequate for the 48 hours fumigation at the temperature above 20°C. The dosage for the tent will be as follows:

$25g \times 224 = 5,600g$

6. Wearing of Gas Mask

Wear a gas mask prior to dosing MB. First connect the mask and canister, press the joint tight around with a clasp. Draw the air-intake plug of the canister and wear the mask in the face. Plug the air-intake once and make sure whether or not you can breathe at all. If you cannot breathe, the gas mask is in working order. If you can breathe at all, grasp tightly the hose connecting the mask and canister. If you can still breathe, either the gas mask does not fit your face or the mask itself is defective. If you cannot breathe at this point, either the mask is not properly connected with the canister is in disorder.

7. Dosing of MB

MB contained in a pressure proof bomb or a can is usually used for fumigation.

When the MB bomb is used, the bomb is placed on a weigh as is shown in Figure 9. One end of a pressure-proof rubber hose is connected with the exit of the bomb while the other end is inserted into a copper tube of 9mm exterior diameter (7mm interior diameter) which is 70 - 80cm long. This copper tube is inserted 50 - 60cm deep into from the top of the stack through the tent. A measured amount of MB is released carefully so that the emitting MB may not splash the tent directly. In case the canned MB is used, the operator goes up the stack of grain, connect the above-mentioned copper pipe, rubber hose, and opener securely and open the can with the opener. The rubber hose for city gas can be usable in this case. In connecting the bomb, and the copper pipe or the rubber hose and the opener together, these must be fastened tightly with fasteners or wires to prevent disconnection.

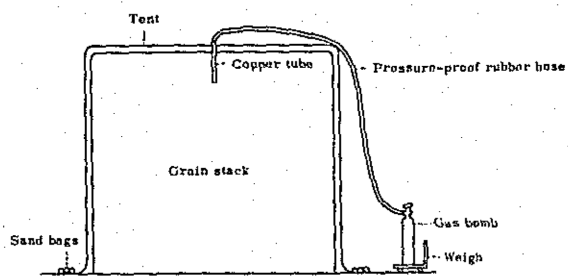

Figure 9 Method of dosing MB from gas bomb

8. Detection of Gas Leakage

Inspection of the possible gas leakage is made by use of the aforementioned detector with special emphasis put on the skirts of the tent. If leakage is found, press sand bags, rearrange the rows or, if necessary, put additional bags to prevent the leakage.

9. Cautions during Fumigation

Careful attention should be paid to ventilation in a warehouse during fumigation. The sign 'Caution Poison' should be put up to keep people off the fumigation site. Occasional checking of gases in a warehouse with a detector is necessary as well as the inspection of gas leakage which, if found, will be urgently coped with by the measures referred to in the preceding chapters.

10. Removal of Tent

When the pipes for measuring gas concentration are arranged, the concentration of remaining gas is first measured by Riken's gas analyser. Next the people around the place of fumigation must be kept away from it and try to keep the warehouse in good aeration. Then more than two operators should wear gas masks according to the foregoing wearing procedure and after removing the sand bags on the hems of the tents, they go up to the tents and tug up the one side and then the other side of the tent. In case the tents are of rectangular shape, lift the longer side up. The tent in lifting is tucked toward the center of the stack as in the manner of folding fans, and then pulled down the stack by one end. Then inspect the life or death of the test insects to ascertain the fumigation effect. For a while, MB gas detection should be continued to see if there is still residual gas in a warehouse. Only after making sure of no gas remaining in the warehouse, people should be allowed to enter. The handling of the fumigated grains should be done at least one day after the removal of tent. Removed tent is conveniently rolled by two operators from one side, while one operator press on the tent sheet to exclude air from being caught within the rolled tent.

IV. PREVENTION OF POISONING

In MB fumigation every possible precaution must be taken to prevent people from poisoning. In any case, one must take great care not to inhale gas. In case of poisoning, proper remedial measures should be taken.

1. Toxic Symptoms

If man continues to inhale MB gas of high concentration of about 1% (about $40g/m^3$), he will suffer from pulmonary edema that leads to eventual death. Brief inhalation of high concentration of MB causes headache, eyeache or obnoxious feeling. Similar symptoms also result from longer exposure to a lower gas concentration. The long exposure to an extremely diluted gas of ca. 35ppm can induce a loss of appetite, unpleasant feeling or headache etc. though such symtpoms disappear soon after stopping inhalation.

2. Medical Treatment

In the case of the poisoning mentioned, the following treatment is necessary for the patients.

(1) The patients must be quickly removed into a ventilated room, kept warm and completely quiet.

(2) When the patients are required to move, they must be carried on a stretcher or on one's back, without having them walk.

(3) Oxygen (air) inhalation is to be applied to the patients.

(4) In case the patient stops breathing, artificial breathing is to be accompanied with oxygen inhalation.

(5) Injections of such medicine as sodium hyposulphite, caffeine, BAL (British Anti-lewisite) is said to be highly effective.

3. Precautionary Measures against Poisoning

The following is to be strictly observed to prevent men from poisoning:

(1) Those who get tired or are not well should not be engaged in fumigation work.

(2) Every possible means must be employed to prevent gas leakage and keep people away from the place of fumigation.

(3) Clothes, shoes, gloves etc. that are smeared with MB splash should be taken off immediately.

(4) In the course of fumigation, one must not fail to wear gas mask. Even if the mask is worn, it should not be used in MB gas of higher concentration. Canisters must be closed tightly after use, and every time when it is used, the hours used must be recorded and it should be replaced well in advance before it become dangerous.