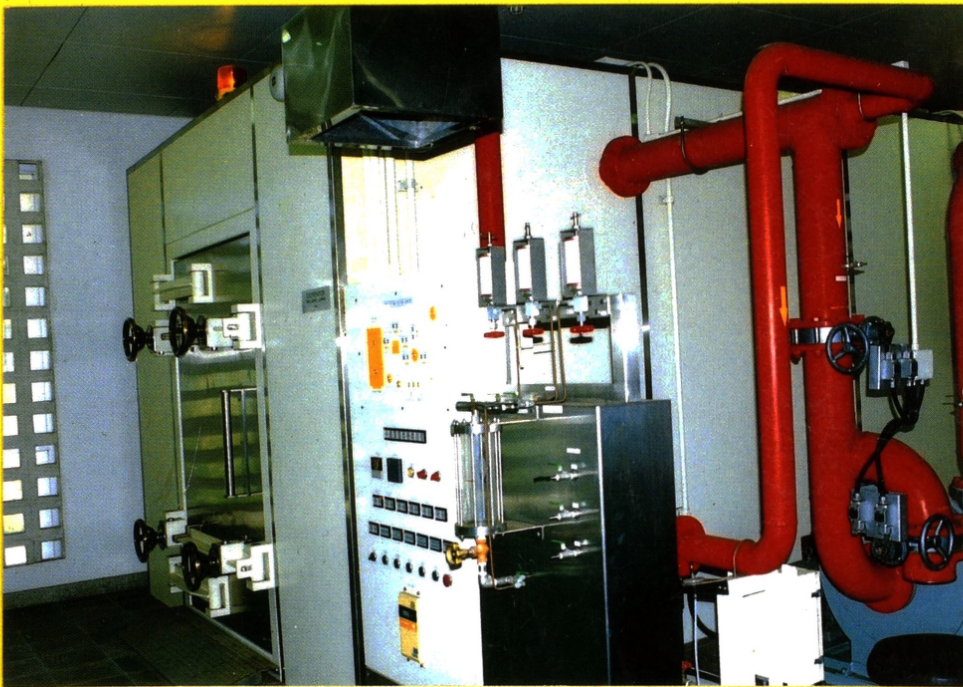


SAFE-GUARD TECHNIQUES IN FUMIGATION



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INTRODUCTION

Fumigants are toxic to humans and other animals as well as to insects. Therefore proper precautions have to be taken in fumigation. Any exposure to fumigants before, during or after fumigation can be harmful. When handling and applying fumigants it is essential to know very well for each fumigant, the level of concentrations above which is not safe to subject workers and also the maximum period of exposure time including repeated exposure during normal working hours. Such concentrations are known as “threshold limits” and are usually expressed in parts per million (ppm) by volume in air. Given below are estimates of “threshold limits” and maximum exposures believed safe for humans (Table 1).

Table 1. Estimates of maximum exposures believed safe for human subjects
(values given in ppm)

Fumigant	Standard value to avoid health damage (Japan)	Maximum con. for up to 15 min. (no more than 4 times per day)	Ceiling value (not to go over a moment)	The time weighted average concentration for 40-hour work/week
Methyl bromide	15	15 ¹⁾		5 ^{1), 2)}
Phosphine	0.3	1.0 ¹⁾		0.3 ^{1), 2)}
Hydrogen cyanide	10	4.7 ²⁾	10 ¹⁾	10 ¹⁾

Source: ¹⁾ American Conference of Government Industrial Hygienist

²⁾ Occupational Safety and Health Act (U.S.A.)

SAFE-GUARD TECHNIQUES TO BE ADOPTED IN FUMIGATION

GENERAL PRECAUTIONS

In any fumigation, large or small no person should work alone. Because poisonous gases are being used, serious consequences may happen if a fumigator becomes sick or faint, and is unable to finish or control the operation. No matter how small the dosage or scale of the work, at least one other person should be present in case of an emergency. All members of fumigation crews should be thoroughly trained in basic first aid, with additional emphasis placed on artificial respiration techniques for gas poisoning. Also persons engaged in fumigation work should have access to an adequately provisioned first

aid kit. Persons working regularly with toxic fumigants should have periodic physical examinations by a physician to check their general health and to detect symptoms that may require the removal of the person from this type of work.

RESPIRATORS (GAS MASKS)

The respirator is the most important piece of equipment used for the protection of persons from fumigants. The full face gas mask with a filter type canister is the recommended type for plant quarantine work (Fig. 1, 2). Check for air tightness of gas mask very carefully when wearing to prevent any inflow of gases into the gas mask (air-tightness is very important) (Fig. 3).

Canisters of this type will give adequate protection for a certain length of time. It is important to check before each fumigation that the canister on the respirator is the correct type for use with the specific gas. The "SANKO" company canister for methyl bromide is black in colour and should be discarded when the weight increases by 5 ~ 7% of the initial weight. In the case of phosphine the canister is light purple in colour and the usage depends on time. Usually the canisters for phosphine gas should be discarded after 60 minutes usage.

Store the canisters plugged perfectly in a cool, dry and well ventilated place away from contamination by any gases.



Fig. 1 Canisters for Methyl Bromide, Phosphine and HCN

In situations where the oxygen concentration is less than 18% or methyl bromide gas concentration is more than 2% or the phosphine gas concentration is more than 0.5%,



Fig. 2 Fixing the canister to the gas mask



Fig. 3 Wearing the gas mask (with the bag, canister etc.)

self-contained breathing apparatus has to be used. This equipment consists of a protective gas mask connected with a air supply cylinder. Check for air tightness of the gas mask when wearing to prevent any inflow of gases into the gas mask (Fig. 4).



Fig. 4 Self-contained breathing apparatus

FUMIGATION

When working with methyl bromide gloves should not be worn, as leather or rubber gloves are likely to retain the liquid methyl bromide and hold it in contact with the skin. In the case of phosphine always wear dry gloves. Wet gloves should not be used as the moisture accelerates production of phosphine gas from the phostoxin tablets.

Methyl bromide is available in 500 g can or in steel cylinder under pressure. Do not give any shock to the methyl bromide cylinder (Fig. 5).

Phosphine is available as Phostoxin or Magtoxin form in tablet, plate or in stripe form (Fig. 6). Store in a cool, dry and well ventilated place; they should not be stored where the temperature exceed 38°C. Do not store in a refrigerator, because of possible condensation. The shelf life of aluminium phosphide is practically unlimited provided original packing remains intact and is stored according to the manufacturers recommendations.



Fig. 5 Transportation of compressed liquid methyl bromide steel cylinder fixing on a cart



Fig. 6 Phostoxin tablet container

Post clearly visible warning signs of “Danger Poison Gas Fumigation in Progress” or “Danger No Admittance” to keep away outsiders (Fig. 7). Warning sign should be removed promptly after fumigation.

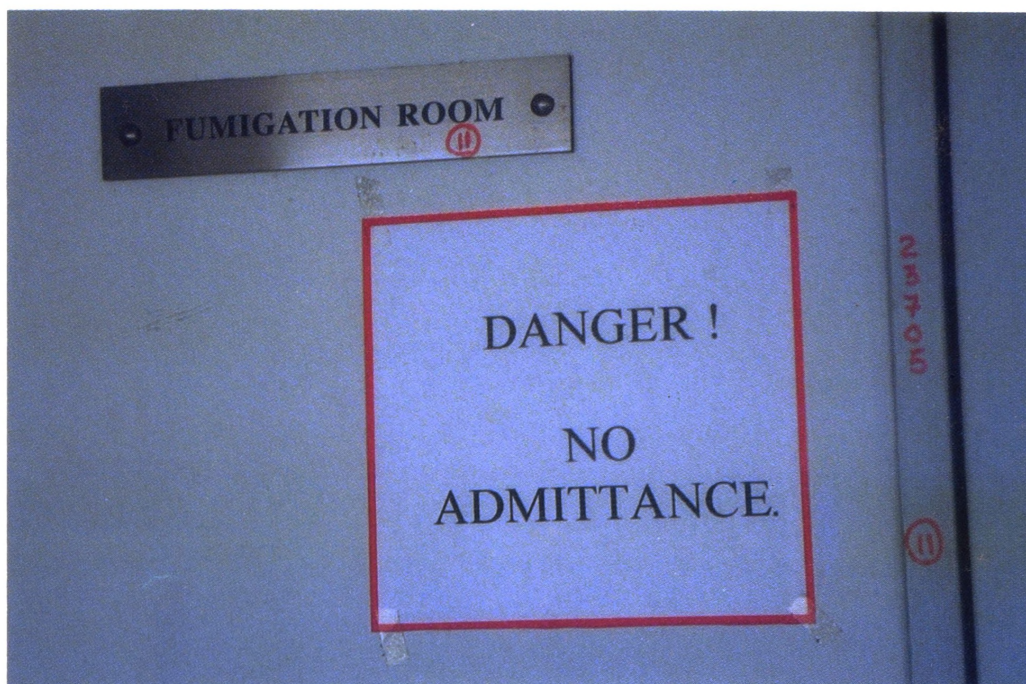


Fig. 7 Warning signs

1. Application of fumigants

Wear the gas mask during application of fumigant and checking of fumigant gas leakage. Confirm that there is no person inside the chamber, before closing the door and around the facility before application of fumigant.

Before application, check the chamber door beading of fumigation chamber and wipe with a clean cloth to remove any dirt.

Close the chamber door properly and lock the door. Remove the key to prevent any accidental opening.

a) Methyl bromide

To apply methyl bromide, connect the “exclusive hose” to the application valve and methyl bromide cylinder properly (Fig. 8) or keep the “can” at the application place (Fig. 9). Check the connector is properly fixed. Also check for the presence of washer before placing the can.

b) Phosphine

In fumigation, place the phostoxin tablets kept in a glass container in fumigation chamber before the chamber door is closed, then the tablets decompose gradually with moisture in the air and phosphine is generated gradually. Phosphine reacts with copper and precious metals, so it can be used only in the anti-metal corrosion type fumigation chamber.

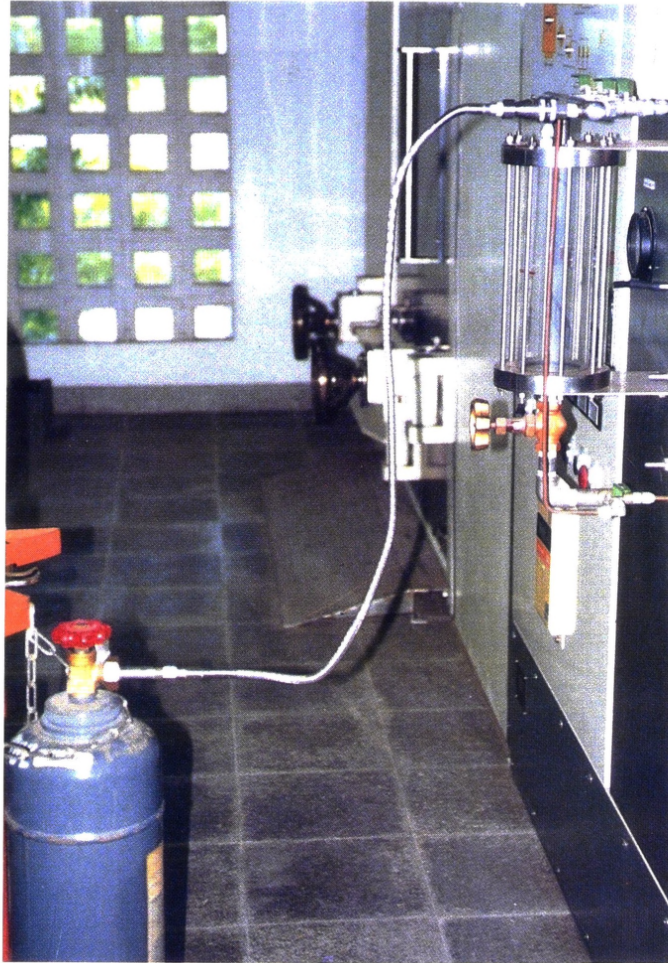


Fig. 8 Application of methyl bromide from steel cylinder

After decomposition (fumigation) the residual material should be buried in the ground to prevent any possibility of human contact.

2. Checking the gas leakages from a chamber or an enclosure

One of the following techniques could be adopted.

- a) Gas leak checker (RIKEN Model GH – 202F)
- b) Halide leak detector
- c) Test paper for phosphine

1) Gas leak checker (Fig. 10)

Gas sensitivity between 200 ppm and 20 ppm can be detected. And is sensitive to methyl bromide, LP gas and ammonia gas. This can be used to locate gas leaks and also to determine the presence of residual gas in treated commodities.

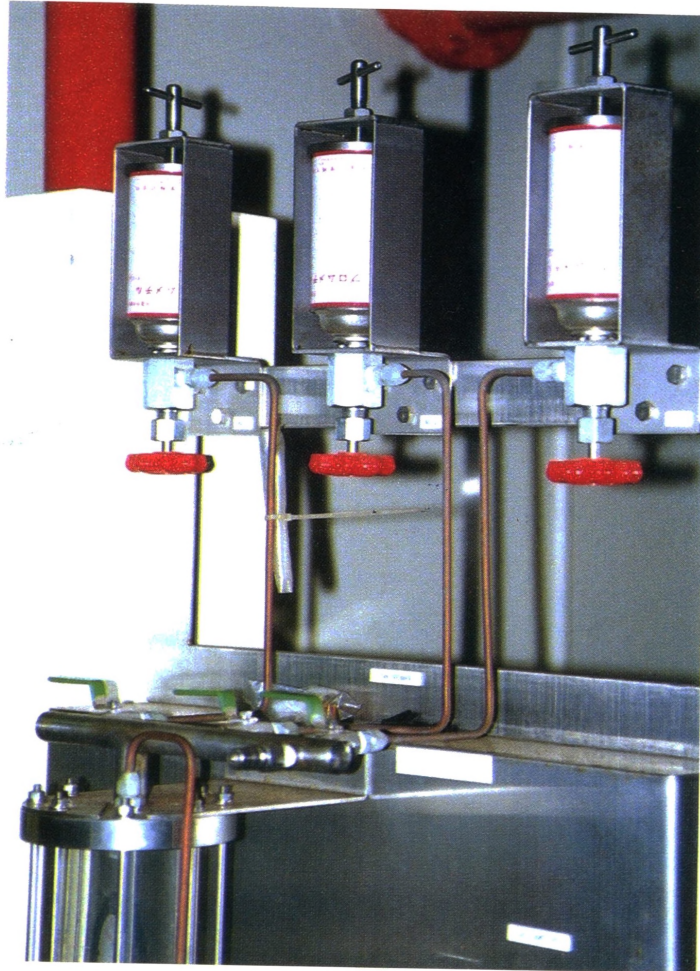


Fig. 9 Application of methyl bromide from 500 g cans



Fig. 10 Checking the door beading with the gas leak checker for methyl bromide gas leaks

2) Halide leak detector (Fig. 11)

Is used extensively to locate gas leaks, but it may be difficult to operate under windy conditions and under high light intensity situations. The degree of colour intensity from green to blue indicates increasing gas concentration (Table 2).



Fig. 11 Halide leak detector

Table 2. Relationship between methyl bromide gas concentration and flame colour

Methyl bromide gas concentration		Flame colour
ppm	mg/l	
0	0.00	no reaction
50	0.19	faint green flame
200	0.78	intense green flame
400	1.55	intense blue – green flame
800	3.11	intense blue flame

When gas leakage is found,

- Tighten the chamber door by turning the door handles if the leaking spot is around the chamber door.
- If a considerable leakage persists, measure the gas concentration in the vicinity and if possible confirm the gas leaking spot to take appropriate countermeasure.
- If required stop the fumigation operation and initiate the exhaust operation of fumigant.

3) Test paper for phosphine

Filter paper soaked in 5% silver nitrate solution can be used to detect phosphine gas. Use a fresh solution always. A colour change from white to black indicates the phosphine content in the air. This method cannot be used under strong ultra-violet radiation.

3. Measurement of fumigant gas concentration

Once the fumigation is over, measure the gas concentration before opening the door of the chamber,

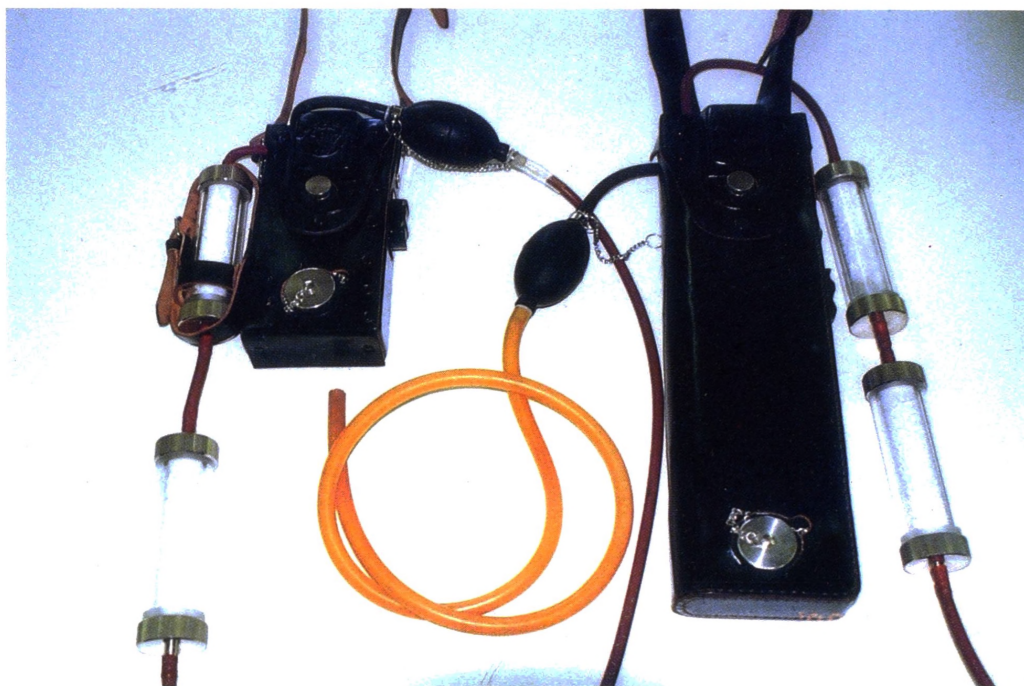


Fig. 12 Riken 18/21 refractometer type gas detector
left: Riken 18 Model, right: Riken 21 Model

- measure the gas concentration inside the chamber using Riken 18/21 refractometer type gas indicator taking gas samples from the sampling ports (Fig. 12). Directly read off the methyl bromide gas concentration before opening the door. Phosphine gas concentration is obtained by multiplying the value with the constant 0.53.
- If the gas concentration is 0 mg/l with the Riken 18/21 refractometer measurement, then use the “Kitagawa” gas detector with the appropriate type of detector tube taking gas samples from the sampling ports and confirm the gas concentration is below 10 ppm methyl bromide or 0.3 ppm phosphine (Fig. 13, 14). Colour change in the detector tube will indicate the gas concentration (Fig. 15).

* Colour change of detector tube

Methyl bromide	white	→	yellow
Phosphine	pale yellow	→	pink

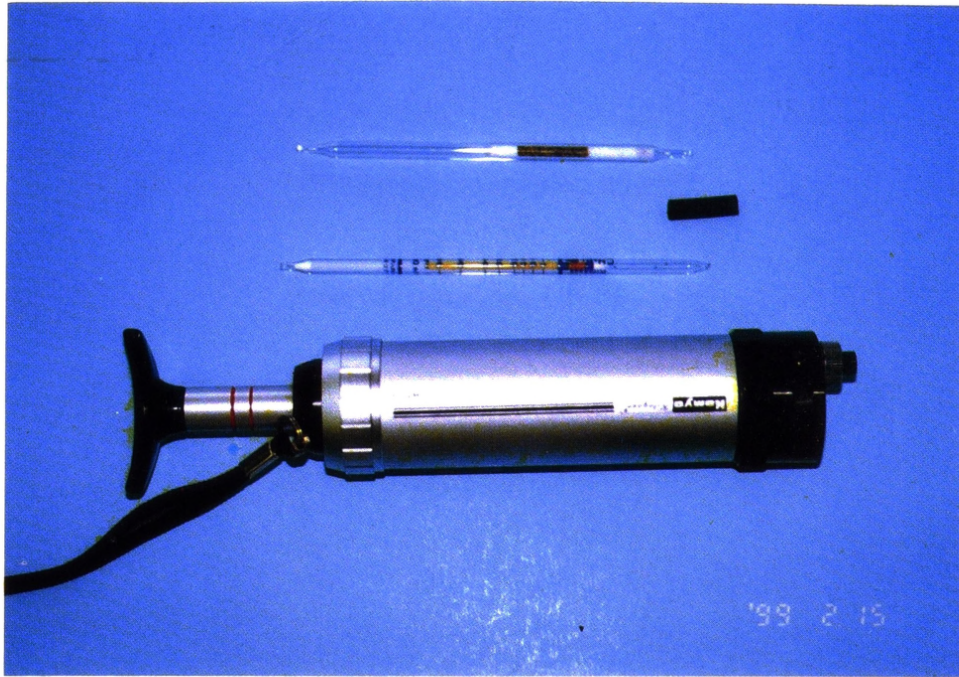


Fig. 13 Kitagawa gas detector and detector tubes
(Upper: pre-treatment tube, Middle: detector tube)

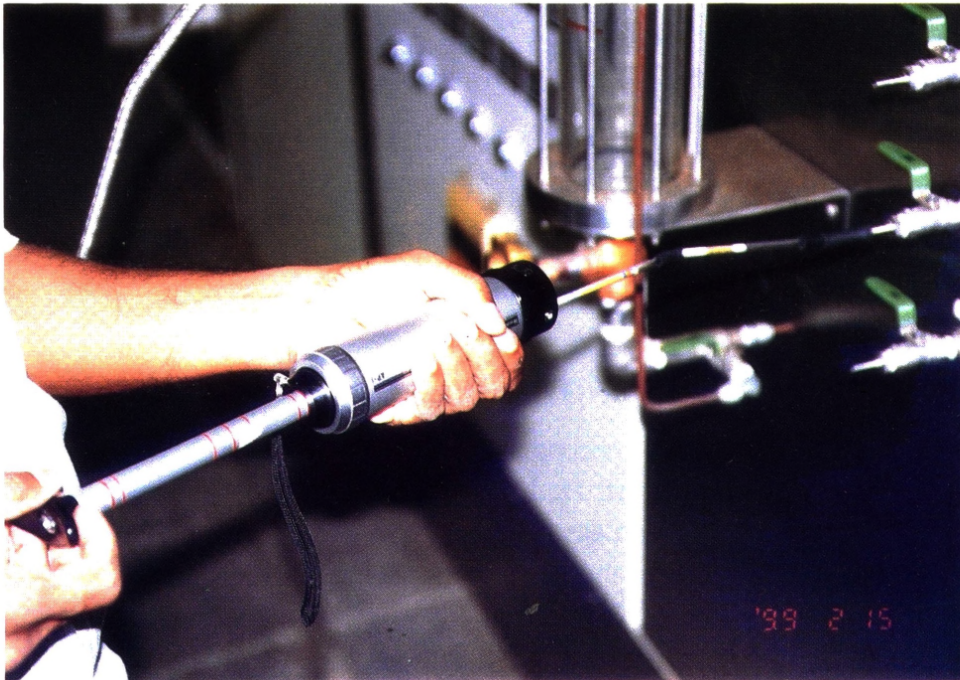


Fig. 14 Measuring gas concentration by Kitagawa gas detector

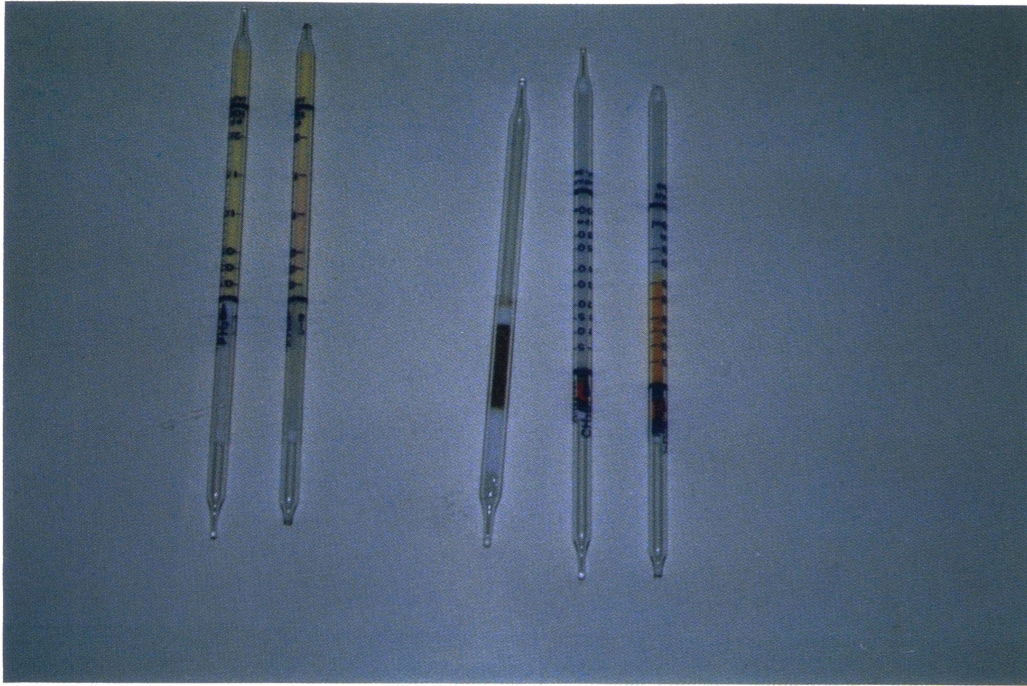


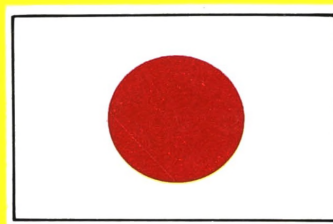
Fig. 15 Colour change in detector tubes by the reaction with fumigant gases (from left): unused detector tube, used tube (for phosphine), pre-treatment tube, unused detector tube, used tube (for methyl bromide)

ROUTINE PRECAUTIONS

- a) Display of the fumigation schedule in advance
- b) Periodic inspection and repairing of the fumigation equipment and safety alarm system
- c) Periodic checking of the air-tightness of the fumigation chamber by using smoke canister or by air-pressure method and mending the chamber with sealing tape, coating agent etc. if there are leaking spots
- d) Ensure a good air-circulation in the fumigation site

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