Donahaye, E.J., Navarro, S., Bell, C., Jayas, D., Noyes, R., Phillips, T.W. [Eds.] (2007) Proc. Int. Conf. Controlled Atmosphere and Fumigation in Stored Products, Gold-Coast Australia. 8-13th August 2004. FTIC Ltd. Publishing, Israel. pp. 429-433

THE FUMIGATION OF FREIGHT CONTAINERS

BERND MUSSMANN AND FRANK ARNOLD

Draeger SafetyAG & Co. KGaA, Revalstrasse 1, 23560 Lübeck, Germany 49-451-882-2940 • www.draeger.com• Frank.arnold@draeger.com

SUMMARY

This presentation addresses the issue of fumigation of freight containers. The large variety of fumigants and the consequences of concentration and clearance measurements are highlighted in detail. A simple kit of measuring devices, which enables these measurements of concentrations and clearance, is broadly discussed.

THE FUMIGATION OF TRANSPORT CONTAINERS / CONCENTRATION MEASUREMENTS - AN OVERVIEW

The fumigation of goods such as grain, wood, coffee, textiles and many other organic/biological materials has been done for decades. In correlation with the increasing use of freight containers for the export of all kinds of goods, the market for fumigation is also continuously increasing. Often fumigation is used as a prophylaxis not only to save the transporting goods, but also to restrict the worldwide migration of storage insects and other pests.

Since the worldwide transport of freight containers has increased so dramatically, over 3,000,000 freight containers arrive at the harbour in Rotterdam, Netherlands every year.

Because this flood of containers is often handled as transit goods, the safety risk moves onto the inshore harbours, trucks and trains, and, lastly, the contents' recipient.

Because of the fumigants' purpose, the main safety risk is that they are often extremely toxic. Not only do they poison their target pests, but may also affect the workers who come into contact with the containers and the transported goods.

The first accidents, which had severe consequences on the health of the workers involved, support the potentially shattering effect of this worldwide problem.

This situation is intensified by the fact that the labelling of fumigated freight containers is often insufficient even though there are international regulations to this effect. It seems that during the offshore transport of containers, more requirements have to be fulfilled. This leads to higher transport costs. So, the labelling will be "forgotten" in order to save money.

One other problem is that sometimes during fumigation in the exporting country, a larger amount of fumigant is put into the container than necessary. Because of this, when the container is opened, accidents can still happen even though the container is well-marked and the required ventilation is done. The residual gases in the container and in the transported goods will have been released directly into the air immediately around the container close to workers.

A study from the Dutch ministry VROM (Ministry of Housing, Spatial Planning and the Environment) shows that of the 3,000,000 containers, which arrive in Rotterdam, Netherlands, 1,000,000 are fumigated. But only 3 % of these are labelled correctly.

The remaining 97 % create an enormous amount of potential safety hazards, which are not only being transported onto ships, trucks and trains in this condition, but also come into contact with the final recipient.

Because of this barrage of illegal fumigations, specific regulatory actions have been initiated worldwide by regulating authorities in the affected countries to correct this problem.

For example, there are quarantine regulations for the import of wood packaging material in Australia, New Zealand, Argentina, Brazil, China, Canada, USA and Mexico. The only methods allowed are boiler pressure impregnation, heating treatment or fumigation with Methyl Bromide or Sulfuryl Fluoride. The type of fumigant depends upon the condition of the transporting goods.

MEASUREMENT OF FUMIGANT CONCENTRATIONS IN FREIGHT CONTAINERS

Well-established authorized fumigants in the market for freight containers are:

> Nitrogen (N_2), Ammonia (NH_3), Methyl Bromide (CH_3Br), Hydrocyanic Acid (HCN), Phosphine (PH_3), Formaldehyde (HCHO), Chloropicrin (CCl_3NO_2), Ethylene Oxide (C_2H_4O), Carbon Dioxide (CO_2), Carbon Monoxide (CO), Sulfuryl Fluoride (SO_2F_2).

This variety of fumigants raises the question: How is it possible to detect the presence of fumigants within the maximum safety limits and acceptable costs?

The measurements necessary include checking the concentration during the fumigation, controlling the exposure to nearby workers and a fumigant clearance measurement for the container after delivery to the recipient and the correct ventilation protocol.

The clearance measurement becomes even more critical when (as mentioned above) after ventilation the fumigants start to evaporate out of the transporting material and niches that were hidden within the piles of stock..

Fumigation with phosphine is performed with an aluminium phosphide fumigant such as Phostoxin® pellets, which are placed onto the freight container's floor. This

material will react with moisture in the air (humidity) and unleash the toxic substance phosphine. Very often too many pellets are placed in the containers. This causes the continuous production of phosphine, which will only stop generating and releasing gas when the saturation point is reached. When the doors are opened or ventilation is started, the chemical reaction will begin again. But when a clearance measurement is done before opening the container, it will give the wrong impression. The safest way is to remove the remaining pellets before emptying the container. This is very often difficult because the pellets were thrown into the container or packed into linen bags or sachets. They are then difficult to locate in the containers. Until the fumigant bag or sachet is located and removed, the fumigation continues and a potential risk for the workers exists.

TEST KIT FOR THE MONITORING OF FUMIGANTS IN FREIGHT CONTAINERS

The brand new "fumigation box" by Draeger Safety AG & Co KGaA, Germany enables the quick and easy measurement of the concentration of fumigants in the freight containers. The content of this box is designed for the normal layperson so that well-trained workers are able to perform this measurement.

The contents consist of the Draeger hand pump Accuro®, a special bar probe for freight containers and the specific Draeger-Tubes, necessary for a fast and easy measurement.

TABLE 1. Draeger-Tubes for use with the Draeger fumigation box

Fumigation-Gas	**Draeger-Tube**	**Part Nr**	**Measuring Range**
Ammonia (NH_3)	Ammonia 5/a	CH 205 01	5 - 700 ppm
Hydrocyanic Acid (HCN)	Hydrocyanic Acid 2/a	CH 257 01	2 – 30 ppm
Formaldehyde (HCHO)	Formaldehyde 0,2/a,	67 33 081	0,2 – 5 ppm
Methyl Bromide (CH_3Br)	Methyl bromide 0,5/a	81 01 671	0,5 – 30 ppm
	Methyl bromide 0,2/a	81 03 391	0,2 – 8 ppm
Phosphine (PH_3)	Phosphine 0,1/a	CH 311 01	0,1 – 4 ppm
	Phosphine 1/a	81 01 801	1 – 100 ppm
	Phosphine 25/a	81 01 621	25 – 10000 ppm
Chloropicrin (CCl_3NO_2)	Chloropicrin	81 01 421	0,2 – 2 ppm
Ethylene Oxide (C_2H_4O)	Ethylene Oxide 1/a	67 28 961	1 – 15 ppm
Carbon Dioxide (CO_2)	Carbon Dioxide 0,1%/a	CH 235 01	0,1 – 6 Vol%
Carbon Monoxide (CO)	Carbon Monoxide 10/b	CH 206 01	10 - 3000 ppm
Sulfuryl Fluoride (SO_2F_2)	Sulfuryl Fluoride-Test	81 03 361	5 – 10 ppm

Normally, gas measurements in freight containers are completed while the container is closed and sealed. This ensures that: the existing concentration of fumigant is monitored and the health burden for the workers is reduced to a minimum.

It is recommended to use the Draeger bar probe for containers by pushing it through a crease or gap beside the sealing rubber gasket on the container doors. It is also possible to drill holes into the containers' exterior shell and sample the gas through these drilled openings.

This procedure depends on the importing country's local regulations. Australia, for example, requires that the sample be taken with drilled holes.

The robustness of the Draeger Bar probe allows for both ways of taking samples.

In the Draeger fumigation box, a measuring strategy for fumigated freight containers is included.

The following procedure is recommended:

1. When the fumigant in the freight container is known because of the label, then evaluate the concentration using the specific Draeger-Tube:

2. When unknown fumigants are in the container or the container is not labelled, and fumigation is suspected, then:

The use of the Draeger Simultantest is the right decision. There are two sets available:

Draeger Simultantest Fumigation:

Ammonia (NH_3)

Hydrocyanic Acid (HCN)

Formaldehyde (HCHO)

Methyl Bromide (CH_3Br)

Phosphine (PH_3)

Draeger Container Fumigation Set 1:

Hydrocyanic Acid (HCN)

Formaldehyde (HCHO)

Methyl Bromide (CH_3Br),

Phosphine (PH_3)

Ethylene Oxide (C_2H_4O)

These Simultantests detect the above mentioned fumigants in the range of their threshold limits. If there is no positive reading visible with these sets, measurements with the following tubes should be made:

TABLE 2

Fumigant	**Draeger-Tube**	**Part Nr**	**Measuring Range**
Ammonia (NH_3)	Ammonia 5/a	CH 205 01	5 - 700 ppm
Hydrocyanic Acid (HCN)	Hydrocyanic Acid 2/a	CH 257 01	2 – 30 ppm
Formaldehyde (HCHO)	Formaldehyde 0,2/a,	67 33 081	0,2 – 5 ppm
Methyl Bromide (CH_3Br)	Methyl bromide 0,5/a	81 01 671	0,5 – 30 ppm
	Methyl bromide 0,2/a	81 03 391	0,2 – 8 ppm
Phosphine (PH_3)	Phosphine 0,1/a	CH 311 01	0,1 – 4 ppm
	Phosphine 1/a	81 01 801	1 – 100 ppm
	Phosphine 25/a	81 01 621	25 – 10000 ppm
Chloropicrine (CCl_3NO_2)	Chloropicrin	81 01 421	0,2 – 2 ppm
Ethylene Oxide (C_2H_4O)	Ethylene Oxide 1/a	67 28 961	1 – 15 ppm
Carbon Dioxide (CO_2)	Carbon Dioxide 0,1%/a	CH 235 01	0,1 – 6 Vol%
Carbon Monoxide (CO)	Carbon Monoxide 10/b	CH 206 01	10 - 3000 ppm
Sulfuryl Fluoride (SO_2F_2)	Sulfuryl Fluoride-Test	81 03 361	5 – 10 ppm

3. Results and consequences

If the presence of a fumigant is verified and the concentration is above the threshold limit value, then the freight container has to be ventilated in accordance with country specific regulations. After that, the freight container must be sealed again and the concentrations checked once again.

REFERENCES

VROM (Ministry of Housing, Spatial Planning and the Environment), Netherlands,(2002) Measuring the amount of gas in import containers, T. Knol-de Vos, October 2002

Agriculture, Fisheries and Conservation Department, Plant and Pesticides Regulatory Division, USA (2004) Implementation of the International Standards for Phytosanitary Measures (ISPM) #15, Guidelines for Regulating Wood Packaging Material in International Trade, June 2004.

TRGS 512, (2002) Begasungen, Technische Regel für Gefahrstoffe,Germany, Mai 2002