Muck O, Stock A (2012) Occupational safety in import containers containing fumigants, other gases and volatile substances: practical experiences. In: Navarro S, Banks HJ, Jayas DS, Bell CH, Noyes RT, Ferizli AG, Emekci M, Isikber AA, Alagusundaram K, [Eds.] Proc 9th. Int. Conf. on Controlled Atmosphere and Fumigation in Stored Products, Antalya, Turkey. 15 – 19 October 2012, ARBER Professional Congress Services, Turkey pp: 193-197

OCCUPATIONAL SAFETY IN IMPORT CONTAINERS CONTAINING FUMIGANTS, OTHER GASES AND VOLATILE SUBSTANCES: PRACTICAL EXPERIENCES

Otto Mück[1]* and Alexander Stock[2]

[1] EWCS GmbH, Südweststraße 19, 28237 Bremen, Germany
[2] PPD/EWS N.V., Postbus 44, 2170 Antwerpen, Belgium
*Corresponding author's e-mail: *o.mueck@ewcs-gmbh.de*

ABSTRACT

In transit fumigation of freight containers is a convenient means of preventing damage by insect pests and their accidental introduction to other countries. On the other side, containers containing hazardous substances including fumigants have become an important occupational safety hazard because most of these containers have not been labeled according to the regulations in force. In 2011, members of the PPD/EWS group performed a total of 123,349 measurements of import containers in different European countries. A total of 17 substances were measured on a regular basis including common fumigants and the most frequently encountered industrial gases and vapours. The results were communicated to the customers in immediately generated on-line gas measuring reports. For serial measurements the preferred technology applied was Selective Ionisation Flow Tube Mass Spectrophotometry plus sensors for low molecular weight gases and lower explosive limit (LEL). Handheld technology such as reactive tubes plus gas pumps, photo ionisation detectors (PID) and others were used. Of the 123,439 containers measured, 13% were rejected because the concentrations of hazardous substances inside were above the respective occupational exposure limits (OEL). In containers with food the proportion of rejected containers was 15 %. The substances found most frequently in concentrations above OEL (in order of importance) were carbon monoxide, 1,2-dichloroethane, formaldehyde, toluene, benzene, and carbon dioxide. Phosphine came in seventh place, methyl bromide in tenth and sulphuryl fluoride in fourteenth place. The origins of most hazardous containers were countries from South East Asia. The applied system of risk assessment and indexation combined with the use of high performance measuring instruments, and state of the art ventilation and gas recapture procedures allows hazardous containers to be handled in a safe and economic way.

Key words: Fumigants, import containers, occupational safety, risk assessment, toxic gasses, gas measurement, methyl bromide, phosphine

INTRODUCTION

In transit fumigation of freight containers is being practiced in order to prevent damage by insect pests. Examples are prevention of the accidental spread of wood destroying insects according to the ISPM 15 standard of the International Plant Protection Convention (IPPC) and quarantine as well as pre-shipment fumigations against post-harvest pest insects. Phosphine is a widespread fumigant for post-harvest treatments of dry commodities such as food and feed grain or cocoa, for example while the use of methyl bromide has been phased out to a large extent due to the Montreal Protocol stipulations on protection of the stratospheric ozone layer. Within the framework of ISPM 15 methyl bromide is still commonly used to fumigate pallets and other packaging made of wood. Fumigation of freight containers should be performed according to an international regulatory framework issued by the International Maritime Organisation (IMO). However, in practice a large portion (presumably about 99 % of all fumigated containers) is not properly labelled (Knol-de Vos, 2002). Some reasons might be prevention of additional cost and possible delays imposed by importers.

In addition, different scientific and practical studies published more recently (e.g. Baur et al., 2006 and Luyts & Mück, 2011) indicate that other hazardous gases and vapours even exceed fumigants in number and importance with regard to occupational safety at the time of opening and unloading import containers from overseas. Practical gas measurements performed by PPD/EWS group companies in different European countries in 2011 confirm these findings.

MEASURING STRATEGY AND EQUIPMENT USED

Risk evaluation with regard to residual gasses or vapours in import containers is performed using Risk Indexes. Measuring frequencies of hazardous substances are determined in relation with a Risk Index per product stream that is based on the cargo description (i.e. articles in the container, supplier and country of origin). As a 100 % safety level would require measuring 100 % of the incoming containers, an acceptable risk indexation system is used in order to reduce the amounts of measurements needed to realize reliable risk control without taking irresponsible safety risks. For practical reasons a three categories risk system is targeted (No Risk / Low Risk / High Risk).

There are two measurement types for hazardous substances: serial and ad-hoc. Serial measurement means large amounts of containers on the same place at the same time. Ad-hoc means few containers at a time. For serial measurement the technologies applied are SIFT (Selective Ionisation Flow Tube Mass Spectrophotometers) plus sensors for gasses with a low molecular weight and LEL (lower explosive limit). Handheld technology used for ad-hoc situations includes PID (Photo Ionisation Detectors) for VOC’s (volatile organic chemicals), Infrared devices for sulfuryl fluoride, and sensors for light substances. Colorimetrical test tubes are mainly used to check and exclude possible interferences.

RESULTS OF MEASUREMENTS

In 2011, members of the PPD/EWS group performed a total of 123,349 measurements of import containers in several European countries (Austria, Belgium, Denmark, Germany, Netherlands, and Spain). From these measurements, 13 % exceeded limit values such as Occupational Exposure Limits (OELs). Depending on the contents of the containers, there were even higher levels of excess of limit values such as food commodities (15 %), electronics (17 %), consumables such as garden furniture, tools and pet equipment (19 %), and shoes with 42 % of excess of limits valid according to the respective occupational safety legislation in force.

The substances most frequently measured and detected in levels higher than legal limits are given in table 1, in order of importance. Apart from VOC's and fumigants, a number of gases with small molecules play an important role. Some sources of these substances have been reliably identified while others sometimes remain questionable up to now. Apart from the frequency of detection of the respective substances in levels above agreed limit values the highest concentration found is given as compared to limits in force in the Netherlands where the highest number of measurements were performed.

Table 2 provides an overview of substances found compared to selected product groups in freight containers. Certainly, this table is far from being complete, but it is good start for understanding hazards that were hardly perceived by anybody ten years ago.

Compared to 2010, the overall picture was similar. By that time the total number of rejected containers was 11 % (N = 42,888 container measurements) compared to 13 % in 2011. Food containers accounted for 20 % (15 % in 2011).

Table 1. Selection of substances detected in freight containers in quantities higher than official limit values (N = 123,349 measurements)

Substance	**Frequency of value transgressions**	**Highest concentration detected**	**Workplace Exposure Limits (Netherlands)**	**Transgression Factor**
Carbon monoxide	5,150	1,000 ppm	25 ppm	40
1,2 Dichlorethane	4,746	152 ppm	1,7 ppm	89
Formaldehyde	4,625	38 ppm	0,1 ppm	380
Toluene	3,435	693 ppm	40 ppm	17
Benzene	3,288	131 ppm	1 ppm	131
Carbon dioxide	3,020	28,674 ppm	5.000 ppm	5.7
Phosphine	1,856	329 ppm	0.1 ppm	3,290
Xylene	1,034	676 ppm	48 ppm	14
Styrene	963	189 ppm	20 ppm	9.5
Methyl bromide	492	82 ppm	0.25 ppm	328
Ammonia	333	361 ppm	20 ppm	18
Low oxygen	278	11 % (lowest)	20.9 %	-
LEL (explosion)	182	59 %	10 %	-
Sulphuryl fluoride	87	15 ppm	3 ppm	5
Chloropicrin	9	26 ppm	0.1 ppm	260
Hydrogen cyanide	2	3 ppm	0.9 ppm	3.3

ANALYSIS OF THE RESULTS AND CONCLUSIONS

The findings of measurement performed during the past two years have provided a sound database of hazardous substance to be found in freight containers. Important insights include the ones listed below:

- Registered fumigants are less frequently found than industrial chemicals such as solvents and others.
- Fumigated containers from overseas (mainly East Asia, South East Asia and India) are very rarely labelled as fumigated.

- Many containers come with a cocktail of several different hazardous substances which may act in a synergistic way to damage human health (e.g. through sensitization).

Table 2. Relationship between hazardous substances detected in freight containers and selected product groups (x = substance found)

Substance	Shoes	Electronics	Wood	Consumables	Textiles	Food	Packaging
Carbon monoxide	X	X	X	X	X	X	X
1,2 Dichlorethane	X	X		X	X		X
Formaldehyde	X	X	X	X	X		X
Toluene	X	X		X	X		X
Benzene	X	X	X		X		
Carbon dioxide	X	X		X		X	
Phosphine			X	X	X	X	X
Xylene	X	X		X			
Styrene	X	X		X			
Methyl bromide	X	X	X	X	X	X	X
Ammonia	X	X		X			
Low oxygene	X				X	X	
LEL		X					
Sulphuryl fluoride	X		X	X			X
Chloropicrine	X	X	X				
Hydrogen cyanide		X					

Fumigated containers constitute a small proportion of hazardous containers. Containers treated with fumigants registered in the European Union (phosphine and sulphuryl fluoride) plus methyl bromide account for slightly less than 2 % of all hazardous containers. Methyl bromide rejection frequencies show a remarkable decreasing tendency with 302 in 2010 and 492 in 2011. In relative numbers this means a reduction from 0.7 % in 2010 to 0.4 % in 2011. Is this perhaps an indicator of (partly) successful methyl bromide substitution as a consequence of the Montreal Protocol? On the other side it is obvious that sulphuryl fluoride (SF) has not taken the place of methyl bromide in container fumigation. One of the reasons is the higher cost of SF compared to methyl bromide and the fact that SF is still not listed in the ISPM 15 standard.

An important conclusion is that standard gas free measurements for single components (performed with gas hand pumps plus measuring tubes) are in most cases not sufficient to protect workers and consumers from hazards due to gases and vapours included in containers or emanating from the goods packed in them. These measurements and formally correct gas free certificates may even generate a false feeling of safety and provoke additional hazards.

Apart from the substances highlighted in this contribution there are others that may appear more or less frequently depending on the cargo and origin of the containers. The SIFT measuring device disposes of a library of about 400 substances so that full scans can provide a broad overview during orientation measurements. This can be completed by using other measuring equipment of high performance. Once the range of substances to be expected has been scaled down, routine measurements can be performed in a few minutes time. Using this approach, occupational safety can be raised to a very high level as large numbers of containers can easily be measured in comparatively short periods of time.

Measures taken to protect workers from hazards caused by inhaling toxic substances include different ventilation methods ranging from simple natural ventilation (opening of container doors for a certain period prior to gas testing) to forced ventilation with special equipment including active carbon filters if required until the concentration has fallen to safe levels. Taking care of hazardous containers in a professional way should be in everybody's mind to protect workers' as well as consumers' health. Using gas detecting devices is only one step to towards this goal.

A long term challenge remains: to influence production procedures of goods in their countries of origin and the way freight is packaged and treated against pest organisms in order to minimize hazards for workers and consumers. Alternatives are available for practically all hazardous substances such as solvent-free glues for shoes, treatments of agricultural commodities based on oxygen depletion or heat treatment of wooden pallets instead of methyl bromide fumigation. It is up to the consumers, importers and government agencies to impose safer procedures and to be willing to pay a little bit more for safe and sustainable production of goods.

REFERENCES

Baur, X et al. (2006) Begasungsmittelrückstände und toxische Industriechemikalien in Import-Containern, Studie des ZfAM, Hamburg, 27 pp.

Knol-de Vos T (2002) Measuring the amount of gas in import containers, Letter report 729/02 IEM, RIVM report 609021025/2003, 45 pp.

Luyts, L and O Mück (2011), Security of containers at terminals in Benelux countries: practical experiences, Zentralblatt für Arbeitsmedizin, Arbeitsschutz und Ergonomie, Heft 12, Band 61, pp. 408-411.