HAZARD SURVEILLANCE: RESIDUAL CHEMICALS IN SHIPPING CONTAINERS

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Preface

In 2011 Safe Work Australia commissioned the Centre for Public Health Research at Massey University to undertake the project: *Hazard Surveillance: Residual Chemicals in Shipping Containers*.

The goals of the study were to:

1. determine the level and determinants of personal (breathing zone) exposure to methyl bromide and other residual chemicals for workers opening, inspecting, and/or unloading fumigated shipping containers
2. identify sources of peak exposure by examining activities and tasks associated with these peaks
3. suggest solutions aimed at reducing peak exposures
4. observe general work practices when workers unpack fumigated shipping containers
5. assess workplace air in warehouses where unloading and storage of goods unloaded from containers takes place, and
6. assess neurobehavioural, respiratory and other potentially relevant symptoms in a small group of workers opening, inspecting, and/or unloading fumigated shipping containers and make comparisons with comparable workers not involved in these activities.

This report summarises the work completed under this contract.

This study did not:

- investigate residual chemical exposures when shipping containers of dangerous goods were unpacked, or
- determine whether or not any relationships between worker exposures and self-reported health symptoms exist.

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Executive summary

Background

Approximately seven million shipping containers pass through Australian ports annually, sourced from a diverse group of overseas countries. For biological security reasons containers and their contents are often fumigated with gaseous pesticides such as methyl bromide and phosphine. In addition to intentionally added fumigants, the chemicals used in the manufacture or packaging of consumer products may off-gas and accumulate in a sealed container. This presents a potential inhalation hazard to persons entering or unloading shipping containers. Recent studies suggest that air concentrations of residual chemicals are present in container air at levels exceeding commonly used occupational exposure limits, with estimates of the proportion of containers affected ranging from a few per cent to as high as 20–30%.

The current study has attempted for the first time to assess workers' exposures to residual chemicals when inspecting, or unloading fumigated shipping containers. This study also assessed health effects and hazard awareness in a small group of workers.

Methods

Recruitment

Six businesses in Melbourne and Brisbane were recruited including one large retail outlet, three distribution centres and two trucking and distribution centres. These businesses were selected on the basis of their willingness to participate in the study and therefore do not represent a random sample.

Containers

A total of 76 containers arriving from overseas were included for personal exposure sampling. These containers were filled with non-palletised cardboard boxes with: metal/glass products (36.8%); plastic/textile products (26.3%); furniture including timber furniture (26.3%); and miscellanies/mixed (30.6%). Most containers sampled originated from China.

Exposure measurements

Video exposure monitoring with photo ionisation detection was used initially in an attempt to identify peak personal exposures. However, as no peaks were detected by the photo ionisation detector (PID) a total of 131 short-term "peak" personal exposure samples were taken periodically during the unloading or inspection of these containers. In addition, 12 samples representing 2–3 hour time-weighted average (TWA) exposures were collected from 10 workers.

Monitoring within warehouses was conducted using the PID. Two further air samples were collected from inside fumigated product boxes containing wooden furniture and additional air sampling was carried out on product boxes containing ethylene vinyl acetate (EVA) foam mats on the basis of health concerns expressed by workers.

Analysis was conducted by using selected ion flow tube mass spectrometry (SIFT-MS) with the following chemicals being analysed: 1,2-dibromoethane, 1,2-dichloroethane, C_2-alkylbenzenes, ammonia, benzene, chloropicrin, ethylene oxide, formaldehyde, hydrogen cyanide, hydrogen phosphide, methyl bromide, styrene and toluene.

Questionnaire surveys

A survey of occupational exposures and health status was conducted in a sample of exposed (those that unload or inspect shipping containers; n=22) and non-exposed workers (n=61). An additional risk management survey was conducted in a small sample of exposed subjects (n=21).

Unstructured interviews and general workplace observations

Informal discussions were held with five experienced managers and 15 workers. In addition the researchers made observations of workers during work shifts.

Results

Personal exposure measurements

Residual chemicals were detected in "peak" personal samples taken in 74 of the 76 containers (97.4%). Toluene was most commonly identified (92.1% of all containers) followed by C_2-alkylbenzenes (73.7%) and methyl bromide (68.4%).

In eight per cent of the containers levels exceeded the Australian workplace exposure standard (WES) for one of the residual chemicals tested (i.e. chloropicrin, 5.3%; and formaldehyde, 2.6%). In one container the air sample reached the applicable Australian short term exposure levels (STEL) for formaldehyde and in another container the inferred STEL of three times the TWA level for chloropicrin was exceeded. In one-third of all containers at least one of the tested residual chemicals in personal air samples exceeded the Dutch Maximum Allowable Concentration (MAC)—an occupational exposure limit often reported in the literature as most of the previous research has been conducted in the Netherlands. The two most common residual chemicals exceeding the MAC were formaldehyde (19.7%) and methyl bromide (18.4%). Containers with outdoor wooden furniture had the highest levels of residual chemicals. Only one container displayed an external notice that it had been fumigated.

Toluene and C_2-alkylbenzenes were most frequently detected (91.7% and 50% respectively) in the 12 TWA samples but levels were low. In no case was an Australian 8 h TWA WES or STEL exceeded. The MAC value was exceeded for formaldehyde in only one sample. None of the containers displayed an external notice that they had been fumigated.

Workplace air sampling

Residual chemicals were not detected by PID measurements in any of the warehouses.

Product sampling

One of the two boxes containing wooden furniture (fumigated offshore) contained chloropicrin (5.29 ppm) and the other box (fumigated onshore) contained methyl bromide (185.8 ppm)—both orders of magnitude higher than the applicable Australian occupational exposure standards. The chloropicrin concentration was also above the National Institute of Occupational Safety and Health (NIOSH) immediate dangerous to life or health (IDLH) level. Within box testing however cannot be compared directly with workplace exposure standards.

Initial attempts to quantify VOC levels from EVA foam mats using the PID resulted in the PID overloading, with levels in excess of 8,000 ppm. Despite further SIFT-MS and gas chromatography–mass spectroscopy (GCMS) analyses the chemicals that contributed to the high peak could not be conclusively identified.

Questionnaire surveys

Exposed workers more frequently reported symptoms such as forgetfulness (9.1% versus 1.6%), forgetting what to say or do (22.7 vs 8.2%), difficulty remembering names and dates (27.3% vs 13.3%) and absent mindedness (9.1% vs 1.7%). Exposed workers also more frequently reported irritant symptoms such as "irritation of the eyes" (13.6% vs 4.9%), "dryness of mouth or throat" (22.7% vs 6.6%), "throat irritation" (13.6% vs 6.6%) and a “runny nose” (27.3% vs 3.3%). There were also large differences for “ever having had asthma” (31.8% vs 13.1%), “asthma confirmed by a doctor” (31.8% vs 11.5%), “asthma attack in past 12 months” (13.6% vs 3.3%), and “medication for asthma” (13.6% vs 4.9%). Due to the low number of workers and the lack of control of confounding however, these results are only indicative of potential differences between exposed and non-exposed workers.

Approximately 70% of the workers had completed specific work health and safety training on unpacking shipping containers. None knew a lot about the risks of fumes in containers but 67% knew a little. Responses to the question on the likelihood of exposure to chemical fumes and the question on how harmful those exposures may be to their health suggested that workers were generally unsure about these issues. Three-quarters of workers either had limited ability or were not able to identify containers off-gassing fumes. Only 14.3% used monitoring devices and only 9.5% ventilated the container. One-third reported use of personal protective equipment. Workers noted that specific safety procedures were provided most of the time. They also noted that safety procedures were followed most of the time. The most significant reason for not taking safety precautions was lack of training (33%), followed by lack of awareness that the container may off-gas chemical fumes (29%).

Workplace observations

Discussions with managers and workers suggested that commercial pressure may occasionally result in containers being released even if levels of methyl bromide are not below 5 ppm. There was also a concern that high levels of fumigants in product boxes may pose a risk for workers opening these boxes. Other concerns included the lack of placards with information on fumigation and the use of refrigerated containers for general use with potential for gasses to be trapped. Also workers being paid on a “piece rate” basis felt they had no option but to continue work even if a problem was discovered. Other observations included a lack of routine use of PIDs to measure residual chemical levels prior to entering a container, high temperatures in the containers, and manual handling of heavy loads. The use of a short strap fixed to the container doors to prevent worker being struck by the doors when opening overfilled containers was not always used.

Conclusions and suggestions for future work

In conclusion this study shows the potential for workers handling shipping containers to be exposed to residual chemicals. It is not clear whether full eight hour shift exposures occur at levels above applicable workplace standards. The few two–three hour TWA shift samples suggest that eight hour shift exposures may be significantly lower than the personal exposures measured using 20–30 seconds grab samples. However only 12 shift samples were collected and none involved workers unloading containers with wooden outdoor furniture which were shown to have the highest levels of fumigants. More generally because containers and workers were not randomly selected results of both grab samples and shift samples may not be representative for the whole industry.

Very high levels of fumigants were present in the small sample of cardboard boxes tested, which is of concern for workers and consumers opening product boxes.

Exposed workers reported symptoms of memory loss, irritation and asthma more frequently than non-exposed workers, but due to the low number of workers surveyed and the lack of control for confounding these data should be considered inconclusive.

Although most workers had received work health and safety training there was still a large degree of uncertainty regarding the risks associated with fumigated containers and their ability to identify fumigated containers. Also appropriate safety precautions were not always taken.

Key suggestions for future work

Based on the study results the following research objectives and methods are suggested:

- To conduct a larger study involving more extensive full-shift personal sampling of workers unpacking a wider and more representative range of containers. This should be followed by a more targeted study to identify peak exposures in any subsets of containers associated with high personal exposure levels. It is not recommended to conduct more sampling in warehouse storage areas.
- To conduct a larger study to assess personal exposure levels of workers and consumers opening "high risk" product boxes.
- To use stainless steel canisters for sample collection in any future exposure studies.
- To minimise the time between sampling and analyses to a maximum of 12 hours.
- To conduct further measurements to identify the specific chemicals associated with the high PID readings of air in boxes with EVA foam mats and to measure personal workers' exposures to these chemicals. In the absence of further measurements it is recommended that additional preventive measures, i.e. consistent use of PIDs and respiratory protection if required, are used in those workplaces where workers unload EVA foam mats.
- To conduct a health survey focussing on neurotoxic and respiratory symptoms in a larger group of workers inspecting and/or unpacking shipping containers. This will allow epidemiological analyses to be conducted with appropriate control for potential confounders. A population sample of 400 exposed and 200 unexposed would provide sufficient power to provide conclusive results.

While this study might present indicative results it has highlighted some potential work health and safety issues. To ensure that workers who unpack shipping containers are adequately protected against risks associated with residual chemicals and manual tasks, it is suggested that work health and safety policy makers and practitioners:

- consistently enforce:
    - existing requirements to label fumigated shipping containers, and
    - health and safety guidelines for inspecting and unpacking shipping containers, which include using gas monitoring devices to test the air in shipping containers prior to and during unpacking operations
- develop guidance that:
    - encourages routine repeat venting until unpacking is completed for tightly packed containers as suggested by existing WorkSafe Victoria guidelines, and
    - sets a time limit (e.g. two hours) after which unpacking should be stopped so that container air can be tested and ventilated again where required
- improve health and safety training for managers and workers inspecting and unloading containers, and
- recommend the use of safety straps when initially opening shipping containers to prevent shifted contents from forcing doors open and contents falling on workers.

1. Introduction

The equivalent of approximately seven million 20 foot containers (measured as 20 foot equivalent units; TEU) pass through Australian ports annually (Ports Australia 2012). Since many shipping containers are fumigated for biosecurity reasons and sealed during transit for an extended period, people opening, inspecting, unloading, or handling contents may be exposed to residual fumigants. Some of the products packed in the containers may also off-gas hazardous chemicals that were used during production processes, such as solvents found in paints, glues and resins. In some cases the fumigants applied or chemicals used during production overseas may be banned in Australia. Containers that have been fumigated should be labelled in accordance with the International Maritime Dangerous Goods Code (International Maritime Organization 2012) but this rarely occurs.

Over the last 10 to 20 years increased awareness of the potential for workers and bystanders to be exposed to residual chemicals has prompted a number of researchers to assess whether or not levels of residual chemicals within shipping containers pose risks to human health. Some of these studies have looked only at fumigants; others have measured both fumigants and other off-gassing hazardous chemicals. Results of these studies will be reviewed below.

1.1 Potential health effects of fumigants

Fumigants are widely used against a large variety of pests and have a remarkable capacity to penetrate porous materials that may house those pests. Fumigants commonly used in international trade include methyl bromide, (MeBr), formaldehyde (CH_2O), phosphine (hydrogen phosphide, PH_3), chloropicrin (Cl_3CNO_2), carbonyl sulphide (OCS) and sulphuryl fluoride (SO_2F_2). The use of dichloromethane (CH_2Cl_2) as a fumigant for imported textiles and household goods has also been reported (Preisser et al. 2011). These fumigants are known to be highly toxic and are rapidly absorbed across the pulmonary membrane, gut and skin and can give rise to (sometimes severe) neurotoxic, respiratory and skin symptoms (Anger et al. 1986; Breeman 2009; Burgess et al. 2000; Drawneek et al. 1964; Magnavita 2009; Preisser et al. 2011; Valcin et al. 2007). Chronic occupational exposures to methyl bromide and sulphuryl fluoride during structural fumigation are associated with significant health effects (Anger et al. 1986; Calvert et al. 1998). Many case-reports have shown severe health problems after accidental exposures to fumigants (Breeman 2009; Burgess et al. 2000; Drawneek et al. 1964; Preisser et al. 2006). For example, 26 case studies from an outpatient clinic specifically investigating fumigant exposures indicated significant impairment among individuals when opening or unloading shipping containers or working with fumigated goods. Workers displayed both acute and chronic neurological, neuropsychological, and respiratory impairment (Preisser et al. 2011). Nine of the 26 patients self-reported exposures to methyl bromide while opening shipping containers and two had exposures to phosphine (hydrogen phosphide) while unloading containers.

Some evidence suggests that certain fumigants may also be carcinogenic. Three epidemiology studies (one a cohort study) have suggested an association between methyl bromide used in agricultural environments and prostate cancer (Budnik et al. 2012). There has also been controversy about the potential role of methyl bromide fumigants in the development of motor neuron disease in a cluster of port workers in Nelson New Zealand (Shaw 2010). However apart from several case studies (Baur et al. 2006; Baur et al. 2010b; Drawneek et al. 1964; Preisser et al. 2011) no studies have systematically assessed the chronic health effects of fumigant exposures in exposed workers handling containers or fumigated products. Nonetheless, exposure to residual fumigants in shipping containers is now sufficiently common and medically complex that a database for patients with fumigant intoxication has been established in Germany (Heblich et al. 2009).

1.2 Other residual chemicals

A wide variety of industrial chemicals will off-gas from consumer products. Under normal circumstances, diffusion into the surrounding air results in undetectable levels of these substances. A 40 foot shipping container packed solid with consumer products may have a very low volume of airspace thus even minimal emissions can result in significantly elevated concentrations in container air. This is exacerbated by potentially low air-exchange rates characteristic of sealed containers.

Aromatic hydrocarbons such as benzene, toluene, xylene, and aldehydes such as formaldehyde are identified frequently as chemicals off-gassed from consumer products. Some of these chemicals are carcinogens or suspected carcinogens and many have the potential in high concentrations to cause serious, irreversible health effects. For example, formaldehyde is classified by the International Agency for Research on Cancer (IARC) as a Group 1 (proven human) carcinogen (IARC Working Group on the Evaluation of Carcinogenic Risks to Humans 2006). Other health effects known to be caused by exposure to formaldehyde include a range of non-malignant respiratory effects including irritation of mucous membranes, asthma, and reactive airways dysfunction syndrome (RADS), and allergic contact dermatitis (Chan-Yeung & Malo 1994).

Other potential chemical hazards include the presence of elevated levels of carbon monoxide and carbon dioxide, low levels of oxygen, or high levels of combustible gas.

1.3 Other hazards

In addition to hazards posed by residual chemicals, other hazards may be present in workplaces where shipping containers are unpacked. This is because these workplaces are high risk environments largely owing to movement of goods with vehicles. Common hazards include: hazardous placement of containers at the work site; falls from height; falling goods; manual handling hazards; slips, trips and falls; inadequate pedestrian and mobile plant separation; palletising of goods for storage or onward transportation; environmental factors such as temperature; diesel exhaust fumes, and removal of shipping containers from a site (WorkSafe Victoria 2010). Possible consequences include collisions between mobile plant and other vehicles or people that result in serious injury; musculoskeletal injuries; and physical fatigue.

1.4 Previous measurement of residual chemicals in shipping container air samples

Four European studies assessing the prevalence and concentration of residual fumigants and other compounds identified in random sealed shipping containers were identified (Baur et al. 2010a; de Groot 2007; Knol-de Vos 2003; Svedberg & Johanson 2011). The abstract of a fifth European study (written in German and unavailable for review) suggests similar experiences in the Port of Genoa to those reported in the other studies discussed here (Tortarolo 2011). A series of measurements were also conducted in five Australian ports in 2007 and 2008 (Frost 2010) and the results are also discussed below.

Rotterdam 2002 (published 2003)

The first of these studies analysed a total of 303 randomly chosen sealed containers arriving in the port of Rotterdam in 2002 (Knol-de Vos 2003). A probe inserted between the door seals permitted field sampling for three commonly used fumigants: methyl bromide (MeBr); formaldehyde (CH_2O); and phosphine (hydrogen phosphide, PH_3). Carbon monoxide (CO), carbon dioxide (CO_2), ammonia (NH_3), explosive gases, and oxygen (O_2) levels were also measured in the field as these are hazards generally associated with confined spaces. Field measurements were performed using a combination of detector tubes (CH_2O, MeBr), a formaldehyde sensor (CH_2O), a formaldehyde Chip Measurement System (CH_2O), a catalytic cell (explosive gases) and electrochemical cell technologies (PH_3, NH_3, and CO_2).

Field measurements were verified for some fumigants by laboratory analyses. Samples taken from a single point in the centre of containers after opening the doors (presumably taken immediately after opening and without the container being vented) were collected in Tedlar bags and analysed for sulphuryl fluoride (SO_2F_2) and methyl bromide via gas chromatography–mass spectrometry (GCMS). Samples were analysed within three days of collection which may have reduced levels within the bags for some substances. The mass spectrometry library was used to identify other chemicals present in samples. Dinitrophenylhydrazine (DNPH) cartridges were used for formaldehyde analyses.

Table 1 provides a summary of the results, taking into account adjustments based on laboratory analyses for methyl bromide, formaldehyde and sulphuryl fluoride and laboratory results combined with visual observations for phosphine (hydrogen phosphide). The authors compared their results to Dutch eight hour time weighted average (TWA) occupational exposure standards, known as the Maximum Allowable Concentration (MAC) values. Australian eight hour TWA Workplace Exposure Standards (WES) (Safe Work Australia 2012) are provided for comparative purposes.

Table 1. Sampling results from 303 random containers tested in Rotterdam, 2002

Residual Chemical	MAC value (ppm)	Positive results	Exceed MAC	WES (ppm)
Methyl bromide	0.25	19	7	5.0.
Formaldehyde	1.00	42	3	1.0
Sulphuryl fluoride	n.s.	-	-	5.0
Phosphine	0.30	28	6	0.3
Ammonia	20	9	0	25
Carbon dioxide	5000	12	5	5000
Carbon monoxide	25	74	41	30
Explosive atmosphere	n.s.	2	NA	n.s.
Oxygen deficient atmosphere	n.s.	2	NA	n.s.

Notes:

MAC = Dutch Maximum Allowable Concentration

WES = Australian Workplace Exposure Standard

n.s. = not specified

Source: adapted from results presented by Knol-de Vos 2003.

The authors noted that methyl bromide, formaldehyde and phosphine were detected in 21% of shipping containers, with levels in 5% of containers exceeding applicable MAC values. Sulphuryl fluoride was not identified in any of the containers. An aggregate 15% of the containers were found to have had low oxygen levels, pose risks of explosion, or have had elevated levels of carbon monoxide or carbon dioxide.

Only three containers displayed any kind of warning sticker – two were painted over and one was in Chinese. The authors noted that staff wore personal protective equipment when opening containers.

Rotterdam 2003–2006 trend analysis

An additional study for which only the summary is available in English was carried out at the same port over the period 2003–2006. The researchers focused on a trend analysis for the fumigants methyl bromide, phosphine, 1,2-dichloroethane, chloropicrin and sulphuryl fluoride (de Groot 2007). The researchers measured 71 containers in 2003, 84 containers in 2004, 76 containers in 2006 and 46 containers in 2006. An increase in containers with detectable fumigant levels was observed (25% in 2003 versus 59% in 2006). This was primarily due to an increase in the number of containers with 1,2-dichloroethane (8% in 2003 versus 32% in 2006). To a lesser extent, phosphine was also detected more frequently. From 2004 to 2006 almost 25% of all containers contained fumigants at levels above applicable MAC values; in 2003 this occurred in only 7% of the containers but analyses for phosphine and chloropicrin were not conducted in 2003.

The authors also tested for 40 other hazardous chemicals, including aromatic and chlorinated hydrocarbons. The percentage of containers with one or more of these hazardous chemicals detected above applicable MAC values increased from approximately 8% in 2003 to 30% in 2006. Percentages of containers where benzene (4% versus 13%) and toluene (2% versus 8%) were detected more than tripled over the study period.

Although the authors note that the selection method used to inspect containers had not changed over the period of the study, it is not clear whether or not the selected containers were a random sample of all containers arriving in the port of Rotterdam. Therefore, the reported numbers of containers where MAC values were exceeded may not be representative of all containers.

Hamburg 2006 (published 2010)

A total of 2113 randomly selected shipping containers entering the port of Hamburg Germany were analysed in 2006 (Baur et al. 2010a). Sampling was conducted by inserting a probe through the doors of sealed shipping containers and collecting gas samples in Tedlar bags. Each bag sample was analysed for fumigants as well as other residual compounds present by selected ion flow tube mass spectrometry (SIFT-MS) and a transportable GCMS.

Sampling results were compared against chronic and acute reference levels rather than applicable work health and safety exposure standards. Chronic reference exposure levels (RELs) defined by the Californian Office of Environmental Health Hazard Assessment (OEHHA) (OEHHA 2012) were used in this study (results are presented in Table 2). These chronic RELs are based on the most sensitive health effect reported in the medical and toxicological literature and are designed as population-based protection standards. Therefore they are significantly lower than the corresponding eight hour TWA WES. The researchers also used acute RELs defined by the OEHHA when available. When these were not available values from the National Institute of Occupational Safety and Health (NIOSH) were used.

Table 2. Results from 2113 containers entering the Port of Hamburg, 2006

Residual chemical	Chronic REL (ppm)	Number in excess	%	Acute REL	Number in excess	%	WES (ppm)
Formaldehyde	0.002	1252	59.3	0.076	n.s.	31	1.0
Benzene	0.018	408	19.3	0.410	n.s.	5	1.0.
Methyl bromide	0.001	294	13.9	1.000	n.s.	1	5.0
Phosphine	0.001	95	4.5	0.300	n.s.	n.s.	0.3
1,2-dichloroethane	0.010	90	4.3	1.000	n.s.	n.s.	10.0
Chloropicrin (trichloronitromethane)	(0.06 ppb)	35	1.7	0.100	n.s.	n.s.	0.1
Ethylene oxide	0.017	27	1.3	0.100	n.s.	n.s.	1.0
Sulphuryl fluoride	0.005	3	0.2	5.000	n.s.	n.s.	5.0

Notes:

REL = Californian reference exposure levels as reported in the study (rounded down)

WES = Australian Workplace Exposure Standard

n.s. = not specified

Source: adapted from results presented by *Baur et al. 2010b*

Residual chemicals were detected in a total of 1684 (79%) shipping containers. The most commonly identified were formaldehyde, benzene, methyl bromide, and hydrogen phosphide (phosphine). Sulphuryl difluoride was identified in three containers. A total of 70% of the containers had one or more residual chemical in excess of chronic reference values. Thirty-six per cent of the containers exceeded acute reference values mostly attributable to formaldehyde (31%) and benzene (5%).

The authors also reported that less than one per cent of containers sampled had levels of residual chemicals that exceeded NIOSH Immediately Dangerous to Life and Health (IDLH) levels (NIOSH 1995). One container had a concentration of phosphine 120 000 times the acute REL of 0.3 ppm and well in excess of the Australian short-term exposure limit (STEL) value of 1 ppm.

Because of the unusual application of the OEHHA RELs as reference values, the results reported in this study are difficult to compare with occupational standards, such as eight hour TWA WES values or the Dutch MAC values used in the previous studies. Reliance on findings based on the use of the OEHHA RELs may overestimate the extent of the risk posed to workers who unpack shipping containers given their relatively low values.

Indicators of recent fumigation such as placards were evident in 3.6% of the containers sampled, but none complied with the International Maritime Dangerous Goods (IMDG) Code.

Gothenburg (2010)

This pilot study was conducted on 101 randomly selected sealed containers arriving into the port of Gothenburg (Svedberg & Johanson 2011). A probe inserted between the door seals permitted air samples to be collected using Tedlar bags. These samples were analysed using Fourier Transform Infrared spectroscopy (FTIR) which is less sensitive and has a higher limit of detection than SIFT-MS. Samples were analysed immediately in an office adjacent to the testing area with results generally available within five minutes. This may have reduced the impact of leaching of residual chemicals from the Tedlar bags which may have affected the findings of the first Rotterdam study.

While the study aimed to identify residual methyl bromide, phosphine, chloropicrin, sulphuryl fluoride, hydrogen cyanide, and carbonyl sulphide (a potential alternative fumigant to methyl bromide and phosphine), FTIR analysis also allowed other residual chemicals to be identified. Results were compared to a number of reference values, including Swedish TWA, ceiling, and STEL values, American Acute Emergency Guidance Levels (AEGL) (National Research Council 2001) values and Californian OEHHA REL values, the latter to allow results to be compared with the Hamburg study.

Only one container had measurable levels of residual fumigants (1 ppm carbonyl sulphide). However detectable levels of hydrocarbons were found in most containers. The authors noted that levels of methanol (78% of containers) and carbon monoxide (45% of containers) never exceeded Swedish STEL values. Unidentified hydrocarbons denoted as octane equivalents based on the limited resolution of the FTIR spectra were detected in 47 containers. Measurements of these hydrocarbons were compared to exposure levels for white spirit. The maximum concentration identified was 491 ppm of white spirit, five times in excess of the Swedish STEL value. Formaldehyde may have been present in two containers at levels of around 1 ppm, which is the approximate detection limit of the FTIR.

Six containers had levels of carbon dioxide slightly elevated above the occupational exposure level.

None of the containers were labelled with information about fumigation.

Australian Customs Study

14 943 containers were tested for the presence of fumigants by Australian Customs between July 2007 and December 2008 (Frost 2010). Air samples collected from sealed shipping containers were analysed by SIFT-MS. Results indicated that 17% (2503) of samples were positive for residual fumigants. Samples were determined to be positive if fumigant levels exceeded the eight hour TWA WES. Formaldehyde accounted for 31% of positive results. Ethylene dibromide (26%), chloropicrin (18%), and methyl bromide (13%) were also commonly found in excess of eight hour TWA WES values.

1.5 Summary and potential implications for Australian workers unpacking shipping containers

Many case reports have shown severe health problems after accidental exposures to fumigants and other residual chemicals from shipping containers, but no studies have systematically assessed health effects in chronically exposed workers handling shipping containers or fumigated products. The health risks for these workers therefore remain largely unknown.

Several studies have examined concentrations of residual chemicals, including fumigants, within shipping containers and these have consistently shown that air samples of a large percentage of shipping containers contain at least trace concentrations of these chemicals. A smaller proportion of containers sampled for fumigants or other residual chemicals exceeded commonly used eight hour TWA workplace standards with estimates ranging from a few per cent to as high as 20–30%. These studies used air samples taken from sealed containers prior to or just after opening them and none of the studies attempted to measure personal exposures and compare the results with appropriate workplace standards. It is therefore unclear whether or not workers are exposed to levels exceeding relevant exposure standards (STEL or eight hour TWA values). Nonetheless previous studies clearly demonstrate the potential for workers opening, inspecting, or unpacking shipping containers to be exposed. Retail workers unpacking shipped products may also be exposed, but in contrast to fumigators and custom officers, retail businesses and their workers may be less aware of the potential for exposures and their risks. Given the hazardous properties of the residual chemicals studied to date and the potential serious health effects they may cause, further research investigating personal exposures is warranted.

The increased awareness of these potential hazards has prompted regulatory agencies including those in Australia (ComCare 2011; Safe Work Australia 2009; WorkSafe NT 2006; WorkSafe Victoria 2009; 2010) to produce guidance notes on the hazards of residual chemicals and fumigants in shipping containers. Retail workers unpacking shipped products may also be exposed, but in contrast to fumigators and custom officers, employers and employees of retail outlets may have a lower awareness of these exposures and their risks.

This study has attempted for the first time to assess workers' exposures to fumigants and other residual chemicals when opening, inspecting, or unpacking fumigated shipping containers. It has also examined differences in the health status of small groups of workers who unpack shipping containers and those who don't in some workplaces.

This study aimed to:

1. determine the level and determinants of personal methyl bromide and other residual chemical exposures for workers opening, inspecting, and/or unloading fumigated shipping containers
2. identify sources of peak exposure by examining activities and tasks associated with these peaks
3. suggest solutions aimed at reducing peak exposures
4. observe general work practices when workers unpack fumigated shipping containers
5. assess workplace air in warehouses where unloading and storage of goods unloaded from containers takes place, and
6. assess neurological, respiratory and other potentially relevant symptoms in a small group of workers opening, inspecting, and/or unloading fumigated shipping containers and make comparisons with comparable workers not involved in these activities.

2. Materials and Methods

2.1 Study design overview

Worker and environmental exposure measurements

Workers who unpacked containers in Melbourne and Brisbane were monitored using video exposure monitoring (VEM). Monitoring was also performed while workers inspected shipping containers. A photo-ionisation detector (PID) was used to provide real-time information on relative levels of residual chemicals. The use of the VEM system was expected to help identify ‘peak exposures’ and trigger the collection of gas samples using a remote activated grab sampler (RAGS). Samples collected using RAGS were analysed using selected ion flow tube mass spectrometry (SIFT-MS) to identify and quantify residual gases and vapours.

Additional gas samples were collected for some workers over typical work shifts of two–three hours to provide information on time weighted average (TWA) exposures. Workplace air in several warehouses was screened for volatile organic compounds (VOCs) and air samples were taken from ethylene vinyl acetate (EVA) mats that had been identified as the source of worker complaints relating to odours and irritation.

Health symptoms

A Health survey questionnaire was developed and administered to both workers unpacking containers and a reference group of workers from the same workplace not engaging in unpacking activities. The survey focused on neurobehavioural symptoms and respiratory health potentially associated with residual chemical exposure.

Work practices

The use of the VEM system was intended to help identify specific work practices that resulted in ‘peak exposures’. Workers who unpacked shipping containers were asked to complete a Hazard survey questionnaire which asked questions on training, controls and procedures used, perceptions of risks, and factors that influence workplace behaviour. Unstructured interviews were conducted with some experienced workers and managers/supervisors on their opinions and experiences unpacking containers. Researchers also observed general work practices noting compliance with guidance materials issued by regulators for the safe unpacking of containers, particularly relating to the management of musculoskeletal risks, heat, and the prevention of loads falling onto workers.

Each element of the study is discussed in greater detail in the following sections.

2.2 Recruitment

The methodology for the study and forms/documents used during the study were approved by the Massey University Ethics Board, Southern A - Application 11/28.

Businesses

Initially eight businesses in the Melbourne and Brisbane metropolitan areas that regularly received containers during January 2012–31 March 2012 were recruited for this study. During the course of the study, one business withdrew and another business changed its operations. The six businesses that participated in the study were:

- one large retail outlet (ANZSIC Level 2 G 41)
- three distribution centres (ANZSIC I 53), and

- two trucking and distribution centres (ANZSIC Level 2 I 46).

Employee numbers for these organisations varied between 50 and 8000 full time equivalent (FTE) staff. Attempts to identify and recruit smaller import businesses were unsuccessful due to logistical problems in coordinating field work at multiple sites. Therefore businesses that regularly received shipping containers from overseas were recruited for this study. Refrigerated containers with frozen cargo were specifically excluded from the study.

Workers

Workers who unpacked shipping containers at the workplaces of participating businesses were asked if they would like to participate in the study by:

- wearing the VEM and RAGS equipment
- wearing the low flow pump and attached sample bag, and
- completing health and hazard surveys.

A total of 16 workers who worked either by themselves or in teams of up to four workers agreed to participate in the exposure assessment part of the study. The workers were a mixture of full-time employees employed by participating businesses, contracted/casual employees, or workers employed by labour hire companies operating within the participating workplaces. The majority of the workers participating were from the latter category. Employment arrangements varied within the same organisation and were site-dependent. Fourteen of these workers agreed to complete the health and hazard questionnaires.

Forty workers who did not unpack shipping containers at these workplaces also completed the health questionnaire.

Given the small number of workers who unpacked shipping containers at the participating businesses, additional workers enrolled in *Certificate III in Warehouse Operations* courses at various NSW TAFE campuses were asked to complete health and hazard surveys. This resulted in the recruitment of eight more exposed subjects and 21 unexposed subjects.

Consent forms were collected from all workers who participated in this study.

2.3 Exposure Measurements

Peak personal exposures

Video exposure monitoring (VEM)

VEM is a personal exposure visualisation method that records worker activity on video while simultaneously measuring and displaying exposure information. VEM creates a permanent video record of the worker performing their job and the exposures associated with the work. For exposures that vary with time and activity VEM provides the ability to view in detail the pattern of exposure and the effect of worker activities as well as any other potential factors that modify exposure intensity. Traditional worker exposure monitoring does not record worker actions, whereas VEM permits the association of exposure peaks with specific tasks/activities to be assessed. The insights gained may permit engineering or other controls to be implemented and the effectiveness of these solutions in reducing exposures to be evaluated. VEM has been employed over the last 20 years to study airborne exposures in a variety of industries with “peak”, i.e. highly variable, exposures (McGlothlin et al. 2010).

The system used for this study included:

- VEM software developed by Purdue University in Indiana (McGlothlin et al. 2010)
- wireless video cameras: High definition colour video cameras were used to record worker activities within and immediately outside the container. Workers wearing the PID

and RAGS equipped backpack were typically visible for the duration of the sampling periods, as well as significant periods prior to and following grab (Tedlar bag) sampling. Video was transmitted to the computer running the VEM software via Wi-Fi

- PID (to assess instantaneous exposures to VOCs) (more information provided below), and
- RAGS (Remote Activated Grab Sampler) (more information provided below).

Photo-ionisation detector (PID)

A TSI Velocicalc 9565X equipped with a VOC probe and 10.6 eV lamp was used. This lamp has sufficient ionization energy to derive readings from many common chemicals found off-gassing from consumer products, including aliphatics (C_4–C_{12}), aromatics (benzene, toluene, xylene), and ketones (acetone, methyl ethyl ketone [MEK]). VOCs with ionization energies higher than 10.6 eV are detected by the PID but at reduced efficiency. The reduced sensitivity for VOCs with higher ionization energies was not considered to be of significance for the study design because the PID readings were not considered to be quantitative (Tedlar/Kynar bag sampling was employed for this purpose) and grab sampling was conducted regardless of whether a PID reading was detected during container unloading. The VOC reading, in parts per million (ppm) isobutylene equivalents, represented the sum (including any positive or negative interaction) of all residual gases present and was used to provide information on potential exposure levels while shipping containers were unpacked. A peak PID reading was intended to be used to manually trigger the grab sample collection taken during unloading. PID readings were transmitted to the laptop using Bluetooth protocols, and the readings integrated into the VEM software.

The PID was used to monitor container air, to provide real-time exposure measurements for VEM and RAGS, and to survey warehouses.

Remote Activated Grab Sampler (RAGS)

For the purpose of this study a RAGS was custom-made to take four independent peak personal exposure air samples in Tedlar or Kynar bags for SIFT-MS analysis. More information on SIFT-MS analysis is presented in the laboratory analyses section.

Bag sampling is often conducted by placing the bag inside a sealed rigid-walled container, such as a suitcase with a gasket closure. A tube from the bag sampling port leads to outside the container. As air is evacuated from the container the ensuing vacuum draws air through the sampling tubing into the flexible bag, which expands and fills the vacuum. RAGS utilises this approach to fill one of four bags contained within the sealed acrylic container with the addition of the capability to trigger each bag sample independently and remotely using a radio frequency signal. Teflon sampling tubes and valves and medical grade stainless steel fittings were used to minimise potential contamination from RAGS and from adsorption or absorption onto the surfaces of the sampler. RAGS was designed so that the four samples did not share any of the tubing or valves, thus eliminating the possibility of cross-contamination.

The PID and RAGS were placed inside a backpack worn by workers (see Photograph 1). Researchers remotely triggered sample collection when peak levels were observed on the PID providing data to the VEM system. Typically samples were collected over a period of 20–30 seconds which provided sufficient sample volume for analysis. Unfortunately there were many instances where VEM was unable to be used when containers were unpacked. This occurred for a number of reasons including occasions when there was electrical interference with the Bluetooth signal, the distance between the container and the receiving computer was too great and/or the workers declined to wear the sampling pack. A small percentage of workers were not willing to wear the RAGS sampler in conjunction with the PID as this made their tasks too difficult e.g. they could not wear it and drive a forklift or get on/off a forklift to load pallets. In these cases researchers carried the sampler and took an air sample from the approximate height/breathing zone of the worker.

Photograph 1. Remote Activated Grab Sampler (RAGS)

Left: RAGS system showing chamber, Tedlar or Kynar bags, and remotely activated pump. *Right:* Backpack as worn by worker showing the PID probe (left) and four inlet tubes for RAGS (right).

When peak exposures were not detected with the PID samples were taken periodically during the unpacking process. These samples were typically taken when the container was opened and when workers had progressed a quarter, half or three-quarters of the way into the container or to the rear wall of the container. When workers inspected containers for biosecurity reasons readings were taken as the worker unsealed and opened the container for inspection.

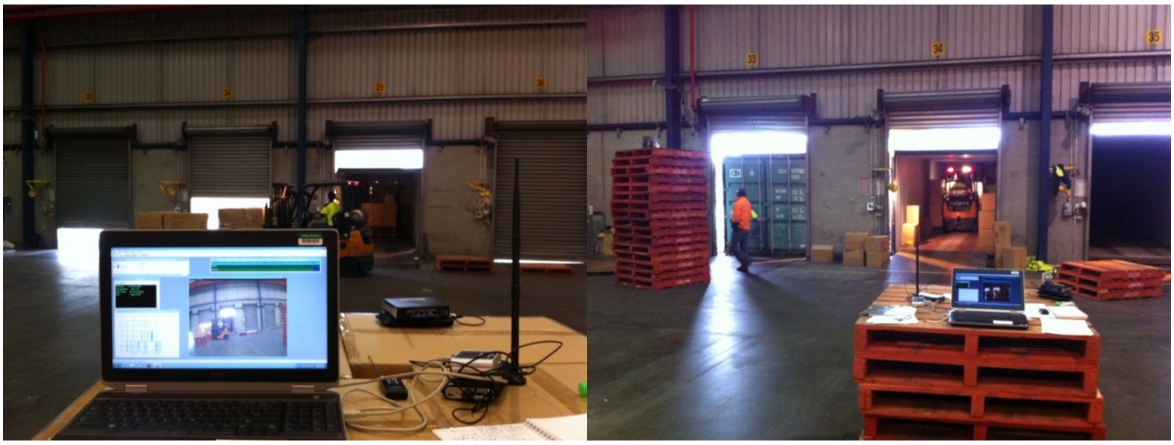
SIFT-MS analyses (more information on SIFT-MS analysis is presented in the laboratory analyses section) retrospectively verified that the lack of PID response was due to generally low levels of residual chemicals (below the levels of detection for the PID).

In summary between one and four samples were collected per container from a mixture of 20 foot and 40 foot containers. A total of 181 personal “peak” exposure samples were collected using VEM and RAGS. Of these samples 50 could not be analysed due to either insufficient sample volumes or bag failures.

Sampling

Sampling commenced each day between 5.30 a.m. and 7.00 a.m. and continued until the containers delivered that day had been unpacked. Photograph 2 provides an example of the sampling set-up. The number of containers tested each day varied due to the rate at which they were released from the docks. Sampling days were random and the percentage of containers sampled over the course of the study represented only a small fraction of the containers unpacked at participating facilities. Over the three months of the study worker exposures were measured during the unpacking of 76 shipping containers in Melbourne or Brisbane.

The containers were opened on arrival and unpacking was delayed in most cases by several hours. However there were occasions when a container arrived and was immediately opened and unpacked. When workers inspected containers sampling occurred as soon as the door was opened.



Photograph 2. The VEM equipment set up for personal exposure monitoring to residual chemicals in shipping containers

Left: VEM computer. *Right:* Warehouse with workers unpacking containers.

One sampling sheet per sample was utilised to document container size, sample identification numbers, sample location (relative to the face and rear of the container), worker identification information, container ID numbers and contents. Information was collected on the presence of external notices displayed on the container noting whether a container had been fumigated. Information on venting times for the containers was not specifically noted.

Time-weighted average (TWA) personal exposure measurements

Two–three hour TWA personal exposures were measured for 10 workers using low-flow portable battery powered pumps to collect air samples in Tedlar or Kynar bags. A five litre Tedlar or Kynar bag was placed inside a small backpack. The inlet tube was placed as close as possible to the worker's breathing zone and the outlet tube was attached to the bag. The pump was switched on when the worker commenced unpacking the shipping container and was left on until container unpacking was completed. When workers stopped for a rest break the pump was switched off until work recommenced. Two workers were sampled twice unloading different containers each time. Samples were analysed using SIFT-MS. More information on SIFT-MS analysis is presented in the laboratory analyses section.

Information was also collected on the presence of external notices displayed on the container noting whether a container had been fumigated.

Workplace air in warehouses

Walk-through surveys were conducted using the PID within warehouses. As no appreciable VOC levels were observed in warehouses the study focused on personal exposure levels associated with unpacking, opening or inspecting of shipping containers.

Product sampling

Two air samples were analysed from two product boxes containing wooden furniture from Vietnam. The product boxes were from two separate shipping containers. Timber from Vietnam was chosen as the researchers knew that it had been fumigated. This information was not available for most other container goods. One box was fumigated in Australia and one box was fumigated offshore. Boxes were randomly chosen from each container.

Additional sampling was carried out on EVA foam mats on the basis of health concerns expressed by workers and supervisors. Initially, the mats were sampled using the PID. Subsequently nine air samples using Tedlar/Kynar bags were collected from product boxes randomly selected from within one container. These samples were analysed for the standard panel of residual chemicals described in the next section on laboratory analyses. At a later stage four more samples were collected using Flexfoil bags and these were analysed for a different set of chemicals including ammonia, acetone, butanone, 2-pentanone, 2-hexanone, formaldehyde, acetaldehyde, acetic acid, methanol, ethanol, 1-propanol and 2-propanol.

An additional sample was collected with a stainless steel Summa type canister. This was analysed at the University of Queensland using GCMS.

Laboratory analyses

Air samples collected in Tedlar or Kynar bags via the RAGS or low flow pump were transported to Christchurch in New Zealand. Samples were analysed by Syft Technologies Ltd within 48 hours of collection. Analysis of the samples was conducted by SIFT-MS which has high sensitivity and specificity. Raw, whole-air samples (i.e. without any sample pre-processing) were injected into the SIFT-MS via a direct injection port, simplifying analysis.

Due to the delay between sample collection and the analysis of the sample there was the potential for the level of certain chemicals to have reduced inside the Tedlar or Kynar sampling bags. Indeed tests by Syft Technologies Ltd showed that this was the case and a copy of the test report is included as Appendix 1. This was in part due to some components having a very short half-life (e.g. 30–50 minutes for formaldehyde) but significant reductions in concentration were also observed for chemicals with a much longer half-life such as hydrogen cyanide (0.9 years) and methyl bromide (0.3–1.6 years). Hydrogen cyanide and formaldehyde levels were reduced by approximately 80% after 24–36 hours (the estimated average time between sample collection and analysis). Results were adjusted accordingly (i.e. laboratory reported concentrations were multiplied by 5.0). Methyl bromide, dichloroethane, ethylene oxide, toluene, benzene, C_2-alkylbenzenes and chloropicrin were all reduced by about 40% and laboratory results were therefore multiplied by 1.67. Phosphine was not affected and no correction was applied. Correction factors based on repeat tests were found to be to be consistent. Styrene, 1,2-dibromoethane and ammonia were not tested. No correction factors were applied for these chemicals and the reported levels are therefore most likely overestimates. This is particularly the case for styrene and ammonia which have half-lives of 7–16 hours and a few days respectively. 1,2-Dibromethane is more stable with an estimated half-life of 40–70 days.

Table 3 lists the residual chemicals that samples were actively screened for in this study. This list was generated after discussions with Safe Work Australia and other government agencies, technical consultations with Syft Technologies Ltd, and reviews of previous studies.

Table 3. Residual chemicals selected for SIFT-MS analyses

Residual chemical	Limit of detection (ppb)
Methyl bromide	20
Hydrogen phosphide	3
Chloropicrin	25
Ethylene oxide	25
1,2-Dichloroethane	10
1,2-Dibromoethane	50
Hydrogen cyanide	3
Formaldehyde	25
Benzene	10
Toluene	5
C_2-alkylbenzenes, including: m-xylene o-xylene p-xylene ethyl benzene	5
Styrene	5
Ammonia	15

ppb=parts per billion

2.4 Health and hazard surveys

Two questionnaires were used as part of this study. A Health survey was completed by both workers who unpacked shipping containers and workers who didn't unpack shipping containers at the workplaces visited. As a low number of workers unpacked containers at worksites where exposures were measured, additional questionnaires were administered to NSW TAFE students as described earlier. The second questionnaire was a Hazard survey which was completed only by those workers who unpacked shipping containers.

Most questionnaires were administered face-to-face. Some were completed by the workers in their own time without the researchers being present. Most respondents took between 30–45 minutes to complete the surveys.

The purpose of the surveys was to obtain indicative data on health risks and risk management practices. The numbers of workers who completed these surveys was low and the results should not be used to make generalisations for broader industry or occupational groups.

Health questionnaire

The Health survey included questions on age, gender, work history and type of work, general health questions, neurobehavioural symptoms, respiratory health and smoking. The questions were taken from validated international questionnaires including EUROQUEST (Gilioli 1993) (neurobehavioural symptoms) and the European Community Respiratory Health Survey (ECRHS) (Sunyer et al. 2000). The Health survey can be found in Appendix 2.

Hazard questionnaire

The Hazard survey was based on a survey developed and used for a previous Safe Work Australia study on asbestos exposures (Pratt et al. 2010) and adapted for this project. The survey included questions on work characteristics and history, frequency of unpacking shipping containers, work health and safety training, knowledge about the risks of unpacking/opening/inspecting containers, risk perception, the ability to identify containers which may give off chemical fumes, and safety procedures. The Hazard survey tool can be found in Appendix 3.

2.5 Unstructured interviews and general workplace observations

Unstructured interviews

Informal discussions were held with five experienced managers/supervisors and 15 workers regarding their workplace observations and experiences while unloading containers. These discussions were not structured and took place in or adjacent to the workplace. The issues discussed included general issues relating to residual chemicals, issues with specific products, issues with products that leaked during transit and issues with information on the fumigation status of shipping containers being unpacked.

General workplace observations

General work practices were observed while workers unpacked containers and were compared to advice provided in Work Safe Victoria guidance (WorkSafe Victoria 2010) particularly relating to the management of musculoskeletal risks, heat, and the prevention of loads falling onto workers.

2.6 Data analyses

Personal exposure data were summarised as the proportion of containers in which personal exposures exceeded one of the following workplace exposure or general population standards:

- the Australian eight hour TWA WES and STEL (Safe Work Australia 2012) if available
- the Dutch MAC. These have been used in several European studies on shipping containers, most notably the studies undertaken in the Netherlands (de Groot 2007; Knol-de Vos 2003). These are considered TWA workplace exposure standards, and
- the chronic inhalation reference exposure levels (chronic RELs) as defined by the State of California, USA. These are levels at or below which no adverse health effects are anticipated following long-term exposure. These are not workplace exposure standards, but presumed to be general population standards. These were used for comparison only because they have been used in a previous container study (Baur et al. 2010a). Their applicability to this type of study is problematic and of questionable value.

Multiple exposure measurements per person and therefore per container were averaged prior to making any comparisons. In some cases multiple samples taken from the same person had both detectable and non-detectable results. In those instances arithmetic means (AM) were calculated assuming a zero concentration for those samples which had concentration below the limit of detection. In addition to expressing exposure levels relative to an occupational standard, average (AM) exposures and standard deviations (SD) were calculated for those containers where at least one of the samples had a detectable result. In cases where multiple exposure levels per container were available the AM was used.

Standard descriptive statistical methods (i.e. AM, SD, maximum values and response choice percentages) were used to summarise the questionnaire data. Due to the low number of respondents no further statistical analyses were conducted.

3. Results

3.1 Exposures to fumigants and other residual chemicals

As noted previously in the materials and methods section the following was undertaken:

1. VEM analyses and RAGS personal "peak" exposure measurements (n=131) while workers unpacked 76 containers
2. twelve, 2–3 hour TWA shift sampling for 10 workers during unloading of 20 containers
3. warehouse sampling
4. within cardboard box (source) sampling, and
5. specific product emission sampling.

The results are summarised as follows:

Personal "peak" sampling (VEM analyses and RAGS collection)

Worker exposures were measured as they unpacked a mixture of 20 foot and 40 foot containers. Containers were of all metal construction and were filled with non-palletised cardboard boxes containing a wide variety of consumer products that originated from China. Of the 76 containers included in the study 28 (36.8%) contained metal/glass products including auto parts, tools, and agricultural parts; 20 containers (26.3%) contained plastic/textile products including safety clothing, storage containers, cabinets, and electrical equipment; 6 containers (8.3%) contained furniture including timber outdoor furniture, hydration blocks, metal furniture and miscellanies furniture; and 22 containers (30.6%) contained miscellanies/mixed loads including household goods, clothes, food in sealed tins, and personal belongings.

Generally no peak exposures were detected using the PID-equipped VEM system. Therefore the RAGS samples were arbitrarily collected as previously described.

The results of the SIFT-MS analyses for the RAGS samples taken while workers unpacked the shipping containers are summarised in Table 4. All SIFT-MS results for RAGS samples are included in Appendix 4.

Table 4. "Peak" personal exposure levels measured in 76 containers

	SIFT-MS levels in positive samples		Number and percentage of containers with residual chemicals above selected reference values							
Residual Chemical	**AM (SD)[a]**	**Max[a]**	**LoD**	**>LoD n (%)**	**REL**	**>REL n (%)**	**MAC**	**>MAC n (%)**	**WES (TWA)**	**>WES n (%)**
1,2-Dibromoethane	0.29 (0.36)	0.90	0.020	5 (6.6)	0.0001[b]	5 (6.6)	0.00025[b]	5 (6.6)	-	-
1,2-Dichloroethane	0.77 (2.40)	9.60	0.003	16 (21.1)	0.1	4 (5.3)	1.7	2 (2.6)	10	0 (0.0)
C_2-Alkylbenzenes	0.25 (0.68)	3.34	0.025	56 (73.7)	-	-	-	-	-	-
Ammonia	0.02 (0.02)	0.08	0.025	12 (15.8)	0.3	0 (0.0)	20	0 (0.0)	25	0 (0.0)
Benzene	0.03 (0.01)	0.05	0.010	8 (10.5)	0.02	6 (7.9)	1.0	0 (0.0)	1	0 (0.0)
Chloropicrin	0.29 (0.54)	1.63	0.050	8 (10.5)	0.00005[b]	8 (10.5)	0.1	4 (5.3)	0.1	4 (5.3)
ethylene oxide	0.01 (-)	0.01	0.003	1 (1.3)	0.018[b]	0 (0.0)	0.47	0 (0.0)	1	0 (0.0)
Formaldehyde	0.50 (0.55)	2.00	0.025	16 (21.1)	0.007	16 (21.2)	0.1	15 (19.7)	1	2 (2.6)
Hydrogen cyanide	0.02 (0.01)	0.03	0.010	3 (3.9)	0.008[b]	2 (2.6)	0.9	0 (0.0)	10	0 (0.0)
Hydrogen phosphide	0.01 (0.03)	0.15	0.005	25 (32.9)	0.0006[b]	25 (32.9)	0.1	1 (1.3)	0.3	0 (0.0)
Methyl bromide	0.33 (0.72)	4.43	0.005	52 (68.4)	0.001[b]	52 (68.4)	0.25	14 (18.4)	5	0 (0.0)
Styrene	0.02 (0.03)	0.10	0.005	30 (39.5)	0.2	0 (0.0)	25	0 (0.0)	50	0 (0.0)
Toluene	0.39 (1.44)	10.46	0.015	70 (92.1)	0.070	24 (31.6)	40	0 (0.0)	50	0 (0.0)
All chemicals tested	**-**	**-**	**-**	**74 (97.4)**	**-**	**58 (76.3)**	**-**	**25 (32.9)**	**-**	**6 (7.9)**

(a) AM (SD) and Max were determined using only samples with detectable results.
(b) REL or MAC values are below the LoD and the number of containers with residual chemicals present at levels greater than REL or MAC values may be underestimated.

Notes:

All reference and measurement values are reported in ppm
AM = arithmetic mean
SD = standard deviation
Max = maximum value
LoD = Limit of Detection
REL = Californian *chronic inhalation* Reference Exposure Level
MAC = Dutch Maximum Allowable Concentration
WES (TWA) = Australian Workplace Exposure Standard (8 h time weighted average)

Comparison with applicable workplace and general population standards

As noted previously, the SIFT-MS results were compared against the following exposure standards:

1. the Australian TWA and STEL WES values (Safe Work Australia 2012);
2. the MAC values used in several large Dutch studies (de Groot 2007; Knol-de Vos 2003); and
3. the OEHHA chronic reference levels used in a large German study (Baur et al. 2010a).

Personal "peak" samples taken in 74 of the containers (97.4% of all containers tested) contained residual chemical levels above the limit of detection. Toluene was the most commonly identified residual chemical (92.1% of all containers) followed by C_2-alkylbenzenes (73.7%) and methyl bromide (68.4%).

In eight per cent of the containers personal "peak" samples exceeded the WES for one of the residual chemicals tested (i.e. chloropicrin, 5.3%; and formaldehyde, 2.6%). In one container the air sample reached the applicable Australian STEL for formaldehyde (2 ppm) and in another container the inferred STEL of three times the TWA level for chloropicrin was exceeded.

Levels above the REL for one or more of the tested residual chemicals were observed in 76.3% of the containers; 47% of the containers had samples taken with two or more residual chemicals in excess of the REL. Methyl bromide was detected at levels above the REL in 68.4% of the containers, followed by hydrogen phosphide (32.9%) and toluene (31.6%).

In approximately one-third of the containers personal samples exceeded the MAC value for at least one of the tested residual chemicals; 11.8% of the containers contained levels above the MAC for two or more of these chemicals. The two most common residual chemicals exceeding the MAC were formaldehyde (19.7%) and methyl bromide (18.4%).

As noted in the data analysis section (Chapter 2.6) when multiple samples were available per person/container these were averaged prior to comparing them with the exposure standards. When the analyses were repeated using only the highest value of up to four exposure measurements taken per container only slightly higher proportions exceeding the REL and MAC were found (MAC, 35.5% versus 32.9%; REL 77.6% versus 76.3%); no differences were seen for comparisons with the WES.

Container contents and levels of residual chemicals

The level of exposure to specific residual chemicals may be dependent on container contents due to differences in fumigation strategies, country of origin, or specific products off-gassing different chemicals. In this study four broad categories of containers were defined on the basis of their contents (see above). In Table 5 the number and percentage of containers with residual chemicals above the WES and MAC are summarised for each of the four container types. Results are shown only for those chemicals where at least one container exceeded the WES or MAC.

Table 5. Number and percentage of container type with residual chemicals above selected reference values

	Containers with metal/glass products (n=28)		Containers with plastic/textile products (n=20)		Containers with wooden and metal furniture (n=6)		Containers with miscellanies/mixed loads (n=22)	
Residual Chemical	**>MAC n (%)**	**>WES n (%)**	**>MAC n (%)**	**>WES n (%)**	**>MAC n (%)**	**>WES n (%)**	**>MAC n (%)**	**>WES n (%)**
1,2-Dibromoethane	2 (7.1)	-	1 (5.0)	-	2 (33.3)	-	0 (0.0)	-
1,2-Dichloroethane	1 (3.6)	0 (0.0)	1 (5.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Chloropicrin	1 (3.6)	1 (3.6)	1 (5.0)	1 (5.0)	1 (16.7)	1 (16.7)	1 (4.5)	1 (4.5)
Formaldehyde	4 (14.3)	0 (0.0)	5 (25.0)	2 (10)	1 (16.7)	0 (0.0)	5 (22.7)	0 (0.0)
Hydrogen phosphide	0 (0.0)	0 (0.0)	1 (5.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Methyl bromide	3 (10.7)	0 (0.0)	2 (10.0)	0 (0.0)	5 (83.3)	0 (0.0)	4 (18.2)	0 (0.0)

Notes:

All reference and measurement values are reported in in ppm

MAC = Dutch Maximum Allowable Concentration

WES = Australian Workplace Exposure Standard (8 h time-weighted average)

The greatest difference was found for containers with furniture including wooden outdoor furniture. For example, personal peak exposure samples from 83% of these containers, or five out of six, exceeded the MAC for methyl bromide versus only 18% or less for containers with other contents. None of the containers exceeded the WES for methyl bromide, so a similar comparison could not be made using WES values. Chloropicrin levels were also more frequently detected above the WES and MAC in these containers (17% versus ≤5%), but only one container for each product category contained chloropicrin above these reference values. 1,2-Dibromoethane was also more frequently detected above the MAC in containers with furniture compared to containers with other contents (33% versus ≤7%). Formaldehyde was found above the MAC in 14–25% of the containers with little difference between containers with different contents. When using only the highest values measured for each person/container (instead of the mean), the results were very similar (data not shown).

Presence of external notices regarding fumigation

With the exception of one container with wooden furniture which was fumigated onshore in Australia, no other containers displayed external notices identifying containers as having been fumigated. Containers displayed dangerous goods notices if appropriate for the goods being shipped but these did not involve notices in relation to fumigation.

TWA shift sampling

Table 6 summarises analytical results for the 12 two–three hour TWA “shift samples” collected from 10 workers while they unpacked 20 shipping containers, separate to those workers unpacking containers when “peak” exposure samples were collected. Repeat samples collected from two workers were treated as independent observations as each repeat sample involved unloading of containers that were different from the first shift sample collected. The containers that were unloaded during shift sampling had metal/glass products (45%), plastic/textile products (5%) and mixed loads (50%). Only those residual chemicals that were detected are shown. Full results are included in Appendix 5.

Table 6. TWA "shift sample" measurements (n=12)

				Number and percentage of containers with residual chemicals above selected reference values						
Residual Chemical	**AM (SD)[a]**	**Max[a]**	**LoD**	**>LoD n (%)**	**REL**	**>REL n (%)**	**MAC**	**>MAC n (%)**	**WES**	**>WES n (%)**
1,2-Dichloroethane	0.53 (-)	0.53	0.003	1 (8.3)	0.1	1 (8.3)	1.7	0 (0.0)	10	0 (0.0)
C_2-Alkylbenzenes	0.03 (0.03)	0.08	0.025	6 (50.0)	-	-	-	-	-	-
Benzene	0.08 (-)	0.08	0.010	1 (8.3)	0.02	1 (8.3)	1.0	0 (0.0)	1	0 (0.0)
Formaldehyde	0.73 (-)	0.73	0.025	1 (8.3)	0.007[b]	1 (8.3)	0.1	1 (8.3)	1	0 (0.0)
Methyl bromide	0.12 (-)	0.12	0.005	1 (8.3)	0.001[b]	1 (8.3)	0.25	0 (0.0)	5	0 (0.0)
Toluene	0.22 (0.39)	1.36	0.015	11 (91.7)	0.070	6 (50.0)	40	0 (0.0)	50	0 (0.0)
All chemicals tested	**-**	**-**	**-**	**11 (91.7)**	**-**	**7 (58.3)**	**-**	**1 (8.3)**	**-**	**0 (0.0)**

(a) AM (SD) and Max were determined using only samples with detectable results

(b) REL values are below the LoD and the number of containers with residual chemicals present at levels greater than REL values may be underestimated

Notes:

All reference and measurement values are reported in ppm

AM = arithmetic mean

SD = standard deviation

Max = maximum value

LoD = Limit of Detection

REL = Californian *chronic inhalation* Reference Exposure Level

MAC = Dutch Maximum Allowable Concentration

WES = Australian Workplace Exposure Standard (8 h time-weighted average)

Toluene was measured at trace levels in 11 of the 12 TWA shift samples and in most cases it was detected in combination with a second residual chemical, generally a C_2-alkyl benzene. An absence of any detectable residual chemicals was noted for only one of the shift samples. In no case was an Australian eight hour TWA WES or STEL for any residual chemical exceeded. The MAC value was exceeded for formaldehyde in one of the shift samples.

The 20 containers that were unloaded during the TWA shift sampling did not display external notices in relation to fumigation.

Workplace air sampling

A number of warehouses were surveyed with the PID for ambient levels of VOCs. As VOCs were not detected by the PID no further sampling was undertaken.

Product sampling

Outdoor furniture

Two air samples were taken from product boxes within containers (source samples). The results are presented in Table 7. The box sampled from a container that had been fumigated offshore had a level of chloropicrin 50 times greater than the WES or MAC. The chloropicrin concentration was also well above the NIOSH immediate dangerous to life or health (IDLH) level of 2 ppm. The level of methyl bromide in this product box was also above the WES and MAC. 1,2-Dibromoethane and formaldehyde levels were above the MAC but not the WES.

Table 7. Residual chemical levels measured in two product boxes containing imported timber from Vietnam

Residual Chemical	Fumigated in Australia	Fumigated offshore	MAC	WES
1,2-Dibromoethane	<LoD	1.30	0.00025	-
1,2-Dichloroethane	0.09	0.31	1.7	10
C_2-Alkylbenzenes	0.06	9.15	-	-
Ammonia	<LoD	0.03	20	25
Benzene	<LoD	0.03	1.00	1
Chloropicrin	<LoD	5.29	0.1	0.1
Ethylene oxide	<LoD	<LoD	0.47	1
Formaldehyde	0.66	0.97	0.1	1
Hydrogen cyanide	<LoD	<LoD	0.9	10
Hydrogen phosphide	0.00	0.01	0.1	0.3
Methyl bromide	185.8	14.3	0.25	5
Styrene	0.01	0.08	25	50
Toluene	0.31	0.77	40	50

Notes:

All reference and measurement values are reported in ppm

MAC = Dutch Maximum Allowable Concentration

WES = Australian Workplace Exposure Standard (8 h time-weighted average)

LoD = Limit of Detection.

Of interest, the personal “peak” exposure level measured for the worker unloading the container with products fumigated offshore was also high at 1.6 ppm for chloropicrin and 4.4 ppm for methyl bromide. The level of methyl bromide in the product box fumigated in

Australia was 35 times greater than the WES and 700 times greater than the MAC. The personal “peak” exposure level measured for the worker unloading the container with product boxes fumigated in Australia was 1.2 ppm.

The reason for the large difference in methyl bromide concentrations between both boxes may be because methyl bromide in the offshore container has gone through more half-lives than the onshore container. These measured levels are not worker exposure levels but are useful for understanding source concentrations and demonstrate that there is a potential risk to workers unpacking shipping containers.

Samples from packs of EVA Foam mats in shipping containers

In response to worker concerns of chemicals off-gassing from EVA foam mats, samples were taken to assess source emissions.

Initial attempts to quantify VOC levels using the PID resulted in the PID overloading, with isobutylene equivalent VOC levels in excess of 8000 ppm. Subsequently, nine air samples were collected and analysed by SIFT-MS for the standard panel of residual chemicals. Trace levels of toluene were found in all samples, and traces of C_2-alkylbenzenes, ammonia, formaldehyde, hydrogen phosphide were found in some samples (data not shown). Two samples contained methyl bromide at levels exceeding the MAC of 0.25 ppm (0.37 ppm and 0.51 ppm, respectively) but none exceeded the WES (5 ppm).

Four more air samples were collected from four EVA foam mats and these were analysed for a different set of chemicals selected to maximise the chances of finding the specific chemicals causing the high peaks measured by the PID. The results from SIFT-MS analyses of air samples are presented in Table 8.

Table 8. Exposure levels (ppm) measured from four EVA Foam mats

Chemical	EVA-1	EVA-2	EVA-3	EVA-4
Ammonia	12.3	14.0	12.5	12.9
Acetone	0.40	0.18	0.17	0.14
Butanone	0.02	0.02	0.02	0.02
2-Pentanone	0.02	0.02	0.02	0.02
2-Hexanone	0.03	0.02	0.02	0.02
Formaldehyde	0.04	0.04	0.04	0.04
Acetaldehyde	0.17	0.14	0.14	0.13
Acetic acid	0.06	0.08	0.07	0.08
Methanol	0.08	0.09	0.10	0.08
Ethanol	0.21	0.23	0.24	0.21
1-propanol + 2-propanol	0.16	0.02	0.03	0.02

Levels of most measured chemicals were low. The highest levels were detected for ammonia at levels below the Australian eight hour TWA WES value of 25 ppm, but Tedlar, Kynar and Flexfoil Plus bags aren’t suitable for sampling ammonia as levels rapidly decrease within these sampling bags. The reported ammonia levels are likely to underestimate ammonia concentrations present in the samples collected. To overcome these sampling problems we also collected a sample with a stainless steel Summa type canister. This was analysed at the University of Queensland. However the sample overloaded the GCMS and therefore no further quantitative data are available. At this stage it is unclear which chemicals in addition to ammonia contributed to the high peak measured by the PID.

3.2 Health and hazards surveys

Health survey

As noted previously, a total of 22 workers (14 on-site workers, eight part-time TAFE students) who unpacked shipping containers and therefore were considered “exposed workers” completed the Health survey. An additional 61 workers from warehouse and distribution centres (40 on-site workers and 21 part-time TAFE workers) who did not unpack shipping containers and therefore were considered “unexposed workers” also completed the health survey and were used as a reference group.

The questionnaire used for this survey focussed on neurotoxic, irritant and respiratory symptoms because many of the fumigants and other residual chemicals have neurotoxic or irritant properties. Questions regarding general health and head injuries were also included because these conditions may affect the reporting of neurological symptoms. However, given the small sample size their effects were not assessed in the current study. Given the small number of exposed workers the differences noted between exposed and non-exposed groups should be treated as indicative findings only. These results should not be generalised to industry or occupational groups.

In cases where respondents did not answer a specific question or did not complete a section of the questionnaire data were treated as missing. The denominators may therefore differ for some items.

Demographic and work characteristics

Responses to questions on demographic and work characteristics are presented in Table 9. There were slightly higher proportions of men and current smokers in the exposed workers group and this group had also worked more years in their current job compared to unexposed workers, but differences were generally small. The small sample size prevents controlling for demographic differences between groups. Therefore, some of the differences in health status between the exposed and unexposed workers that are discussed below may be associated with differences in gender, smoking or other confounders rather than exposures alone.

Table 9. Demographic and work characteristics for exposed and unexposed workers

	Exposed workers (n=22)		Unexposed workers (n=61)	
Sex	**n**	**%**	**n**	**%**
Male	17	77.3	37	60.7
Females	5	22.7	24	39.3
Smoking status	**n**	**%**	**n**	**%**
Current smoker	7	31.8	17	27.9
Ex-smoker	2	9.1	13	21.3
Non-smoker	13	59.1	31	50.8
Other job at present	1	4.6	5	8.2
	AM	**SD**	**AM**	**SD**
Age	35.8	12.8	35	9.8
Years worked in current job	3.2	3.2	2.7	2.8
Hours/week in current job	36.5	6.6	37.5	6.5
Type of work[a]	**n**	**%**	**n**	**%**
Freight handlers and shelf fillers	9	41	38	62
Fork lift driver	3	14	-	-
Supervisor/manager	2	9	2	3
Workers attending TAFE courses	8	36	21	34

(a) More than 90% were employed by a retail and wholesale distribution centre

Notes:

AM = arithmetic mean

SD = standard deviation

General health symptoms

The responses to the questions on general health symptoms are presented in Table 10. Approximately half of all workers used prescription drugs in the past 12 months, with no difference between exposed and unexposed workers. Cardiovascular disease, diabetes, muscular tremors and sensation of pins and needles were reported more frequently by unexposed workers. Exposed workers more frequently reported concussions but no difference was observed for the occurrence of head injuries. More than 95% of all workers reported that their self-perceived health was good to very good and no differences were seen between groups. The majority of workers also felt good about life in general (63.6% and 65.6% for exposed and unexposed workers respectively). Exposed workers reported having enough sleep and waking up feeling refreshed often or always at slightly higher rates than unexposed workers.

Table 10. General health in exposed and unexposed workers

	Exposed (n=22)		Unexposed (n=61)	
Symptom	**n**	**%**	**n**	**%**
Prescription drugs in past 12 months	10	45.5	31	50.8
Ever had cardiovascular disease (1 ms)	1	4.6	6	10
Ever had diabetes (2 ms)	0	0	5	8.3
Ever had muscular tremor (1 ms)	1	4.6	6	10
Ever had sensation of pins and needles	2	9.1	11	18
Ever had neurological degeneration	0	0	0	0
Ever had epilepsy, Parkinson's, ALS, MScl	0	0	2	3.3
Ever had Alzheimer's	0	0	0	0
Ever had other dementia	0	0	0	0
Ever been in a coma	0	0	1	1.6
Ever had chronic fatigue (1 ms)	0	0	2	3.3
Ever had other neurological disease	0	0	0	0
Ever had neurological injury	1	4.6	3	4.9
Ever had head injury (1 ms)	3	14.3	7	11.5
Ever had concussion (1 ms)	6	28.6	9	14.8
Ever had major depression	2	9.1	5	8.2
Ever had anxiety	1	4.6	3	4.9
Ever had learning disability or attention deficit disorder	0	0	0	0
Ever had other emotional problems (2 ms)	0	0	3	4.9
Ever had learning disability	1	4.6	0	0
Self-perceived health	**n**	**%**	**n**	**%**
Very good	5	22.7	23	37.7
Good	16	72.7	37	60.7
Poor	1	4.6	1	1.6
Very poor	0	0	0	0
Self-perceived health now vs 5 years ago (1 ms)	**n**	**%**	**n**	**%**
Better	5	22.8	14	23
About the same	15	68.2	36	59
Worse	1	4.5	11	18
Much worse	1	4.5	0	0
Feeling about life in general	**n**	**%**	**n**	**%**
Good	14	63.6	40	65.6
Average	7	31.8	19	31.1
Not very good	0	0	1	1.6
Bad	1	4.6	1	1.6

	Exposed (n=22)		Unexposed (n=61)	
Feeling about life now vs 5 years ago (1 ms)	**n**	**%**	**n**	**%**
Better	10	45.4	31	51.7
About the same	10	45.4	25	41.7
Worse	1	4.6	3	5
Much worse	1	4.6	1	1.6
Enough sleep	**n**	**%**	**n**	**%**
Never	0	0	2	3.3
Rarely	7	31.8	21	34.4
Often	14	63.6	27	44.3
Always	1	4.6	11	18
Wake up feeling refreshed	**n**	**%**	**n**	**%**
Never	2	9.1	5	8.2
Rarely	5	22.7	25	41
Often	15	68.2	22	36.1
Always	0	0	9	14.8
	AM	**SD**	**AM**	**SD**
How many hours sleep per day	7	1	7	1.4

Notes:

AM = arithmetic mean
SD = standard deviation
ALS = amyotrophic lateral sclerosis
MScl = multiple sclerosis
ms = missing observation(s).

Neurobehavioural symptoms

The responses to the questions on neurobehavioural symptoms are presented in Table 11. The categories “often” and “very often” were combined as relatively few workers reported they experienced specific symptoms “very often” in recent months. In general, most symptoms were not reported often and differences between exposed and non-exposed workers were generally small. The greatest and most consistent differences for reporting symptoms often were related to symptoms associated with memory e.g. forgetfulness (9.1% versus 1.6%), forgetting what to say or what to do (22.7 versus 8.2%), difficulty remembering names and dates (27.3% versus 13.1%) and absent mindedness (9.1% versus 1.7%). The number of years that exposed workers had these symptoms ranged from eight (absent mindedness) to 20 years (forgetfulness, forgetting what to say or what to do, difficulty remembering names and dates). Given that exposed workers on average only worked three years in the current job (Table 9) with the majority not having worked in the current trade/occupation for more than 10 years (see Section 4.2.2, Table 14) it is not likely that these symptoms are related to their current job (although it cannot be excluded). As prevalence data were based on only a few positive responses the results should be treated as inconclusive.

Table 11. Neurobehavioural symptoms in exposed and unexposed workers

	Exposed workers (n=22)				Unexposed workers (n=61)			
	Seldom	Sometimes	Often	Years[a]	Seldom	Sometimes	Often	Years[a]
Symptoms	n (%)	n (%)	n (%)	AM (SD)	n (%)	n (%)	n (%)	AM (SD)
Dropping things unintentionally	15 (68.2)	5 (22.7)	2 (9.1)	6.3 (1.8)	44 (72.1)	13 (21.3)	4 (6.6)	6.1 (11.0)
Weakness of arms and feet	15 (68.2)	7 (31.8)	0 (0.0)	5.0 (4.2)	43 (70.5)	17 (27.9)	1 (1.6)	2.4 (2.7)
Decreased sensation in arms and legs	20 (90.9)	2 (9.1)	0 (0.0)	-	57 (93.4)	4 (6.6)	0 (0.0)	0.6 (0.3)
Numbness or heaviness in arms or legs	16 (72.7)	5 (22.7)	1 (4.6)	2.5 (0.7)	50 (82.0)	10 (16.4)	1 (1.6)	1.9 (2.0)
Tingling in arms or legs	16 (72.7)	4 (18.8)	2 (9.1)	6.5 (2.1)	52 (85.3)	8 (13.1)	1 (1.6)	1.5 (1.1)
Problems with balance	19 (86.3)	2 (9.1)	1 (4.6)	6.5 (5.4)	50 (82.0)	10 (16.4)	1 (1.6)	2.9 (2.1)
Changes in sense of smell or taste	20 (90.9)	0 (0.0)	2 (9.1)	10.0 (-)	53 (86.9)	8 (13.1)	0 (0.0)	1.8 (1.5)
Decreased sensation on face	21 (95.4)	1 (4.6)	0 (0.0)	-	61 (100)	0 (0.0)	0 (0.0)	-
Difficulties controlling hand movements (1 ms)	21 (100)	0 (0.0)	0 (0.0)	-	57 (93.4)	4 (6.6)	0 (0.0)	1.4 (1.2)
Slowness in carrying out daily activities	16 (72.7)	6 (27.3)	0 (0.0)	3.0 (-)	48 (78.7)	13 (21.3)	0 (0.0)	4.8 (7.3)
Trembling of hands	19 (86.3)	2 (9.1)	1 (4.6)	-	57 (93.4)	2 (3.3)	2 (3.3)	12.8 (20.1)
Headache	10 (45.5)	10 (45.4)	2 (9.1)	12.0 (10.4)	25 (41.0)	28 (45.9)	8 (13.1)	9.4 (12.7)
Sweating for no obvious reason	20 (90.9)	2 (9.1)	0 (0.0)	-	52 (85.2)	4 (6.6)	5 (8.2)	9.1 (9.4)
Nausea	18 (81.8)	4 (18.2)	0 (0.0)	10.0 (7.1)	46 (75.4)	13 (21.3)	2 (3.3)	4.0 (7.6)
Stomach pains	18 (81.8)	3 (13.6)	1 (4.6)	10.0 (7.1)	51 (83.6)	8 (13.1)	2 (3.3)	9.1 (14.7)
Dizziness	11 (50.0)	9 (40.9)	2 (9.1)	5.8 (3.3)	48 (78.7)	10 (16.4)	3 (4.9)	2.2 (2.9)
Shortness of breath without physical exertion	20 (90.9)	2 (9.1)	0 (0.0)	3.0 (-)	53 (86.9)	7 (11.5)	1 (1.6)	5.2 (4.3)
Heart fluttering (palpitations)	18 (81.8)	4 (18.2)	0 (0.0)	5.0 (-)	56 (91.8)	3 (4.9)	2 (3.3)	5.8 (3.2)
Ringing in ears (tinnitus)	17 (77.3)	4 (18.2)	1 (4.5)	5.0 (0.0)	55 (90.1)	4 (6.6)	2 (3.3)	4.0 (4.1)
Feeling of general exhaustion	14 (63.6)	6 (27.3)	2 (9.1)	4.3 (2.2)	41 (67.2)	13 (21.3)	7 (11.5)	4.4 (9.2)
Loss of sexual interest (1 ms)	13 (61.9)	7 (33.3)	1 (4.8)	2.3 (0.6)	46 (75.4)	12 (19.7)	3 (4.9)	7.6 (9.8)

Symptoms	Exposed workers (n=22) Seldom n (%)	Sometimes n (%)	Often n (%)	Years[a] AM (SD)	Unexposed workers (n=61) Seldom n (%)	Sometimes n (%)	Often n (%)	Years[a] AM (SD)
Lowered alcohol tolerance (1 ms)	16 (76.2)	4 (19.0)	1 (4.8)	2.5 (0.7)	55 (90.1)	4 (6.6)	2 (3.3)	2.1 (1.3)
Diarrhoea	17 (77.3)	5 (22.7)	0 (0.0)	-	51 (83.6)	10 (16.4)	0 (0.0)	16 (15.1)
Constipation (1 ms)	18 (85.7)	2 (9.5)	1 (4.8)	35.0 (21.2)	53 (86.9)	7 (11.5)	1 (1.6)	20.8 (17.6)
Loss of appetite	17 (77.3)	4 (18.2)	1 (4.5)	10.0 (-)	50 (82.0)	9 (14.7)	2 (3.3)	2.6 (2.8)
Feeling of a tight band around head	20 (90.9)	1 (4.5)	1 (4.6)	-	54 (88.5)	6 (9.9)	1 (1.6)	1.7 (2.2)
Difficulty getting started at work (2 ms)	18 (81.8)	3 (13.6)	1 (4.6)	3.0 (-)	47 (79.7)	11 (18.6)	1 (1.7)	1.4 (1.0)
Feeling irritable	15 (68.2)	5 (22.7)	2 (9.1)	23.8 (16.5)	39 (63.9)	19 (31.2)	3 (4.9)	4.4 (5.5)
Feeling depressed	19 (86.4)	2 (9.1)	1 (4.5)	4.5 (2.1)	46 (75.4)	12 (19.7)	3 (4.9)	7.8 (8.7)
Feeling impatient	13 (59.1)	8 (36.4)	1 (4.5)	13.0 (12.6)	40 (65.6)	18 (29.5)	3 (4.9)	4.7 (8.3)
Being upset by trivial things	14 (63.6)	6 (27.3)	2 (9.1)	12.5 (10.6)	40 (65.6)	20 (32.8)	1 (1.6)	8.8 (13.4)
Feeling restless	14 (63.6)	7 (31.8)	1 (4.6)	-	38 (62.3)	21 (34.4)	2 (3.3)	7.8 (9.4)
Rapid changes in mood	18 (81.8)	3 (13.6)	1 (4.6)	6.0 (1.4)	45 (73.8)	14 (22.9)	2 (3.3)	3.3 (3.2)
Feeling of detachment	20 (90.9)	0 (0.0)	2 (9.1)	6.0 (1.4)	52 (85.3)	6 (9.8)	3 (4.9)	11.4 (11.2)
Lack of drive	14 (63.7)	5 (22.7)	3 (13.6)	4.1 (3.0)	38 (62.3)	15 (24.6)	8 (13.1)	3.6 (5.4)
Lack of interest in social activities	14 (63.6)	6 (27.3)	2 (9.1)	5.7 (4.0)	41 (67.2)	18 (29.5)	2 (3.3)	3.4 (3.7)
Difficulty in controlling anger	17 (77.3)	3 (13.6)	2 (9.1)	9.0 (3.6)	54 (88.5)	7 (11.5)	0 (0.0)	2.7 (4.2)
Forgetfulness	13 (59.1)	7 (31.8)	2 (9.1)	15.9 (19.9)	40 (65.6)	20 (32.8)	1 (1.6)	17.9 (15.7)
Having to write notes to remember things	15 (68.2)	5 (22.7)	2 (9.1)	5.8 (2.5)	45 (73.8)	12 (19.7)	4 (6.5)	6.9 (10.0)
Forgetting what you were about to say or do	12 (54.6)	5 (22.7)	5 (22.7)	19.1 (18.6)	39 (63.9)	17 (27.9)	5 (8.2)	7.9 (10.1)
Difficulty in concentrating	13 (59.1)	5 (22.7)	4 (18.2)	12.2 (11.3)	44 (72.1)	15 (24.6)	2 (3.3)	7.5 (8.7)
Daydreaming	16 (72.8)	3 (13.6)	3 (13.6)	14.5 (14.8)	39 (63.9)	17 (27.9)	5 (8.2)	8.9 (9.7)
Feeling confused when trying to concentrate	15 (68.2)	6 (27.3)	1 (4.5)	9.5 (7.8)	49 (80.3)	9 (14.8)	3 (4.9)	3.9 (3.6)

Symptoms	Exposed workers (n=22) Seldom n (%)	Sometimes n (%)	Often n (%)	Years[a] AM (SD)	Unexposed workers (n=61) Seldom n (%)	Sometimes n (%)	Often n (%)	Years[a] AM (SD)
Difficulty remembering names and dates	11 (50.0)	5 (22.7)	6 (27.3)	14.6 (20.4)	37 (60.7)	16 (26.2)	8 (13.1)	9.2 (13.2)
Absent-mindedness (1 ms)	17 (77.3)	3 (13.6)	2 (9.1)	7.8 (4.0)	47 (78.3)	12 (20.0)	1 (1.7)	14.1 (12.3)
Difficulty remembering what was read or seen on TV	15 (68.2)	5 (22.7)	2 (9.1)	5.8 (2.5)	43 (70.5)	14 (22.9)	4 (6.6)	19.6 (17.6)
Other people complaining about your memory	15 (68.2)	6 (27.3)	1 (4.5)	4.5 (2.8)	56 (91.8)	4 (6.6)	1 (1.6)	2.5 (0.7)
Falling asleep when not in bed	12 (54.5)	8 (36.4)	2 (9.1)	4.6 (3.9)	40 (65.6)	13 (21.3)	8 (13.1)	11.5 (15.0)
Unusual tiredness in the evening	13 (59.1)	6 (27.3)	3 (13.6)	4.1 (3.3)	38 (62.3)	18 (29.5)	5 (8.2)	1.5 (1.6)
Sleepiness	10 (45.5)	10 (45.4)	2 (9.1)	4.6 (3.3)	34 (55.7)	20 (32.8)	7 (11.5)	3.2 (5.1)
Feeling tired when woken up	10 (45.4)	6 (27.3)	6 (27.3)	4.8 (3.3)	24 (39.4)	26 (42.6)	11 (18.0)	4.4 (6.9)
Lack of energy	10 (45.4)	11 (50.0)	1 (4.6)	5.3 (4.5)	30 (49.2)	27 (44.3)	4 (6.5)	7.2 (11.9)
General weariness (or tiredness)	11 (50.0)	10 (45.4)	1 (4.6)	6.0 (4.8)	29 (47.5)	27 (44.3)	5 (8.2)	5.7 (11.2)
Needing more sleep than you used to	10 (45.5)	7 (31.8)	5 (22.7)	4.8 (3.7)	35 (57.4)	14 (22.9)	12 (19.7)	1.4 (1.0)
Difficulty falling asleep	15 (68.2)	4 (18.2)	3 (13.6)	4.0 (2.8)	40 (65.6)	14 (22.9)	7 (11.5)	6.2 (7.6)
Broken sleep	15 (68.2)	5 (22.7)	2 (9.1)	5.6 (5.4)	30 (49.2)	21 (34.4)	10 (16.4)	7.1 (9.2)
Waking up too early	13 (59.1)	5 (22.7)	4 (18.2)	7.4 (5.2)	35 (57.4)	17 (27.9)	9 (14.7)	7.0 (13.6)
Nightmares	18 (81.8)	3 (13.6)	1 (4.6)	20 (-)	52 (85.3)	9 (14.7)	0 (0.0)	14.3 (12.8)
Snoring someone else has complained about	14 (63.6)	3 (13.7)	5 (22.7)	4.2 (4.8)	42 (68.8)	15 (24.6)	4 (6.6)	8.4 (12.5)

(a) Number of years that symptoms have been experienced

Notes:

AM = arithmetic mean

SD = standard deviation

ms = missing observation(s)

Symptoms in recent months

Responses to questions on symptoms in recent months are presented in Table 12. Workers were asked about the frequency of symptoms in recent months as they are easier to recall by most workers and are therefore less likely to be biased. This approach is often used for symptoms that are relatively common. Symptoms were broadly related to irritation, being sensitive to physical factors, light and foods and nervousness. Exposed workers appeared more likely to frequently (i.e. often and very often) report symptoms of irritation such as irritation of the eyes (13.6% versus 4.9%), dryness of mouth or throat (22.7% versus 6.6%), throat irritation (13.6% versus 6.6%) and a runny nose (27.3% versus 3.3%). As noted previously these results are based on very few responses. Both groups responded similarly to questions on sensitivity to physical factors, light and foods, and questions related to nervousness.

Table 12. Symptoms experienced in recent months, sensitivities to light, noise and physical factors, and levels of nervousness

	Exposed workers (n=22)				Unexposed workers (n=61)			
	Seldom n (%)	Sometimes n (%)	Often n (%)	Very often n (%)	Seldom n (%)	Sometimes n (%)	Often n (%)	Very often n (%)
How often in recent months were symptoms experienced during or directly after work:								
Irritation of the eyes (1 ms)	14 (63.6)	5 (22.7)	2 (9.1)	1 (4.6)	36 (60.0)	21 (35.0)	2 (3.3)	1 (1.7)
Feeling drunk w/o drinking alcohol	22 (100)	0 (0.0)	0 (0.0)	0 (0.0)	56 (91.8)	5 (8.2)	0 (0.0)	0 (0.0)
Dryness of mouth or throat	11 (50.0)	6 (27.3)	4 (18.2)	1 (4.5)	41 (67.2)	16 (26.2)	3 (4.9)	1 (1.7)
Throat irritation	12 (54.6)	7 (31.8)	3 (13.6)	0 (0.0)	49 (80.3)	8 (13.1)	3 (4.9)	1 (1.7)
Runny nose	8 (36.4)	8 (35.4)	2 (9.1)	4 (18.1)	41 (67.2)	18 (29.5)	0 (0.0)	2 (3.3)
Unpleasant taste in mouth	12 (54.6)	9 (40.9)	0 (0.0)	1 (4.5)	49 (80.3)	11 (18.0)	1 (1.7)	0 (0.0)
Sensitive to the following factors:								
Bright lights	14 (63.6)	5 (22.7)	1 (4.6)	2 (9.1)	35 (57.4)	13 (21.3)	5 (8.2)	8 (13.1)
Traffic noise or loud noises	13 (59.1)	4 (18.2)	5 (22.7)	0 (0.0)	38 (62.3)	11 (18.0)	8 (13.1)	4 (6.6)
Strong smells	14 (63.6)	5 (22.7)	0 (0.0)	3 (13.6)	28 (45.9)	20 (32.8)	4 (6.6)	9 (14.7)
Rough fabrics next to skin	17 (77.3)	2 (9.1)	2 (9.1)	1 (4.5)	41 (67.2)	9 (14.8)	6 (9.8)	5 (8.2)
Heat	12 (54.6)	4 (18.2)	5 (22.7)	1 (4.5)	26 (42.6)	22 (36.1)	6 (9.8)	7 (11.5)
Cold	13 (59.1)	3 (13.6)	6 (27.3)	0 (0.0)	29 (47.6)	21 (34.4)	6 (9.8)	5 (8.2)
Tobacco smoke	13 (59.1)	5 (22.7)	1 (4.6)	3 (13.6)	23 (37.7)	19 (31.1)	7 (11.5)	12 (19.7)
Certain foods	18 (81.8)	2 (9.1)	2 (9.1)	0 (0.0)	40 (65.6)	13 (21.3)	3 (4.9)	5 (8.2)

	Exposed workers (n=22)				Unexposed workers (n=61)			
	Seldom n (%)	**Sometimes n (%)**	**Often n (%)**	**Very often n (%)**	**Seldom n (%)**	**Sometimes n (%)**	**Often n (%)**	**Very often n (%)**
Nervousness:								
Nervous person	14 (63.6)	6 (27.2)	1 (4.6)	1 (4.6)	36 (59.0)	18 (29.5)	6 (9.8)	1 (1.7)
Less capable than others in overcoming problems	15 (68.1)	5 (22.7)	1 (4.6)	1 (4.6)	44 (72.1)	12 (19.7)	4 (6.6)	1 (1.6)
Worry about trivial things	14 (63.6)	4 (18.2)	2 (9.1)	2 (9.1)	41 (67.2)	12 (19.6)	4 (6.6)	4 (6.6)
Feel that something bad may happen	17 (77.2)	3 (13.6)	1 (4.6)	1 (4.6)	40 (65.6)	13 (21.3)	7 (11.5)	1 (1.6)
Feel that trivial problems are too much	19 (86.2)	1 (4.6)	1 (4.6)	1 (4.6)	49 (80.3)	10 (16.4)	2 (3.3)	0 (0.0)
I usually feel insecure	16 (72.7)	4 (18.1)	1 (4.6)	1 (4.6)	47 (77.1)	11 (18.0)	3 (4.9)	0 (0.0)

ms = missing observation(s)

Respiratory symptoms

The responses to the questions on respiratory symptoms are presented in Table 13. As expected for an Australian population sample, the prevalence of asthma and other respiratory symptoms are relatively high. Australia is has a particularly high prevalence of asthma compared to most other countries (AIHW Australian Centre for Asthma Monitoring 2005; Asher et al. 2006). Although not consistent for all symptoms, there are relatively large differences for exposed and unexposed workers for “ever having had asthma” (31.8% versus 13.1%), “asthma confirmed by a doctor” (31.8% versus 11.5%), “asthma attack in past 12 months” (13.6% versus 3.3%), “medication for asthma” (13.6% versus 4.9%). Cough with phlegm experienced on a daily basis was also more frequently reported by exposed workers but wheeze symptoms were less frequently reported. The proportion of workers reporting that symptoms lessened when away from work was also slightly higher in exposed workers compared to unexposed workers, but this was based on only very few positive responses and for cough symptoms the reverse was observed.

Table 13. Respiratory symptoms in exposed and unexposed workers

	Exposed workers (n=22)		Unexposed workers (n=61)	
Symptoms	**n**	**%**	**n**	**%**
Wheeze in the past 12 months	4	18.2	17	27.9
Breathless when wheezy in past 12 months	2	9.1	7	11.5
Wheezing when not having a cold in past 12 months	3	13.7	13	21.3
Woken up with feeling of chest tightness in past 12 months	3	13.6	9	14.8
Woken by an attack of shortness of breath in past 12 months	2	9.1	7	11.5
Woken by an attack of coughing in past 12 months	4	18.2	16	26.2
Ever asthma	7	31.8	8	13.1
Asthma confirmed by doctor	7	31.8	7	11.5
Attack of asthma in past 12 months	3	13.6	2	3.3
Medication for asthma	3	13.6	3	4.9
Cough daily for at least part of the year (1 ms)	3	13.6	7	11.7
Cough up phlegm daily for at least part of the year (1 ms)	4	18.2	5	8.3
Dry cough > 1/month which lessens when away from work (4 ms)	0	0	6	10.2
Cough with phlegm > 1/month which lessens when away from work (5 ms)	1	5.3	5	8.5
Wheeze > 1/month which lessens when away from work (4 ms)	1	5	1	1.7
Breathlessness with wheeze > 1/month which lessens when away from work (2 ms)	1	4.8	1	1.7
Shortness of breath > 1/month which lessens when away from work (3 ms)	1	5	2	3.3
Chest tightness > 1/month which lessens when away from work (3 ms)	0	0	1	1.7

ms = missing observation(s)

Differences in reporting between workers and students

Where part-time students made up approximately one-third of both groups, the analyses were repeated excluding the part-time students. This allowed investigation of potential bias that may have resulted from the mixed sample of on-site workers and part-time TAFE students. These results were highly comparable (data not shown).

Hazard survey

Only exposed workers were asked to complete the Hazard survey. A total of 21 exposed workers (13 full-time workers and 8 part-time TAFE students) completed this survey which asked questions about chemical fumes in shipping containers and questions about unpacking shipping containers. For the purpose of this survey:

- chemical fumes were defined as:
  - trace amounts of gases used to eradicate pests from goods shipped to Australia (fumigants), and
  - solvent vapours that may be given off from recently manufactured products, such as glues used in wood products or oils used on machine parts
- unpacking was defined as entering a container on foot or on a vehicle for the purpose of inspecting, shifting contents, or unloading contents.

The definition of chemical fumes specifically excluded designated dangerous goods and chemical products.

Given the low numbers of workers who completed this survey the results should be treated as indicative findings only and should not be generalised to industry or occupational groups.

In cases where respondents did not answer a specific question or did not complete a section of the questionnaire data were treated as missing. The denominators may therefore differ for some items.

Work characteristics

The responses to the demographic questions and general work characteristics are presented in Table 14. Approximately one-third of respondents had worked less than one year in their current trade/occupation and only 10% worked more than 10 years in the current trade/occupation. The remainder had been employed for 1–10 years. More than 50% of the exposed workers unpacked shipping containers daily. Approximately 85% worked for their employer, and 90% worked with others while unpacking containers.

Approximately 70% of respondents had completed work health and safety training related to unpacking shipping containers. Most of the workers had covered each of the six topics plus one “other” option listed in the questionnaire, suggesting that training has been appropriate although no assessment of the quality of the training was conducted.

Knowledge and perception of risks

The responses to the questions on worker knowledge and perception of risks are presented in Table 15. None of the 21 respondents claimed to know a lot about the risks of fumes in containers, but 67% did claim to know a little. The majority (79%) of those who claimed to know a little had received work health and safety training. Seven per cent claimed to know “not much”; 60% of those workers had received work health and safety training. Of those reporting knowledge, in order of decreasing frequency, this knowledge was obtained from work health and safety training (57%), from my boss (29%), WorkSafe/WorkCover advertising (24%), from co-workers (19%) or other (29%).

One-third had read a code of practice or other guidance on how to manage work health and safety risks when unpacking containers, with the Safe Work Australia code most frequently cited (19%), followed by the State or Territory WorkCover/WorkSafe code or guidance as the next most frequently cited (14%).

Table 14: Work characteristics for workers unpacking containers

Work characteristics	n (%)
Time worked in current trade/occupation	
<3 months	1 (4.8)
3 months – 1 year	6 (28.6)
1–5 years	6 (28.6)
5–10 years	6 (28.6)
>10 years	2 (9.4)
Frequency of unpacking shipping containers	
Daily	11 (52.4)
2–3 times a week	2 (9.5)
Once per week	2 (9.5)
Less than once per week	6 (28.6)
Time worked unpacking containers (1 ms)	
<1 year	7 (35.0)
1–5 years	8 (40.0)
5–10 years	4 (20.0)
10–20 years	1 (5.0)
>20 years	0 (0.0)
Type of employment contract	
Working for employer	18 (85.7)
Working through labour hire company	1 (4.8)
Self-employed and employing others	0 (0.0)
Self-employed working by him/her self	2 (9.5)
Type of contract if working for employer or labour hire company	
Permanent	11 (57.9)
Fixed term contract	1 (5.3)
Temporary contract	7 (36.8)
Work alone or with others (1 ms)	
Alone	1 (5.0)
With others	18 (90.0)
Both alone and with others	1 (5.0)
Completed work health and safety training related to unpacking shipping containers	15 (71.4)
What topics were covered (1 ms)[a]	
Identify containers that may give off fumes	9 (60.0)
Risks of exposures to fumes	9 (60.0)
Properties of specific fumes	7 (46.7)
Selection and use of PPE	12 (80.0)
Administrative controls	11 (73.3)
Reporting incidents	14 (93.3)
Other	3 (20.0)

(a) multiple answers were permitted

Note:

ms = missing observation(s)

Table 15. Knowledge about the risks of inspecting, shifting contents or unloading contents of shipping containers in workers unpacking containers

Knowledge about risks	n (%)
Knowledge of the risks of fumes in containers	
Know a lot	0 (0.0)
Know a little	14 (66.7)
Not much	7 (33.3)
Knowledge obtained about the risks of fumes in containers through:[a]	
Trade training	2 (9.5)
Newspapers or television news	0 (0.0)
WorkSafe/WorkCover advertising	5 (23.8)
Information from trade associations or unions	0 (0.0)
From work health and safety training	12 (57.1)
From my boss	6 (28.6)
From co-workers	4 (19.1)
Other	6 (28.6)
Most useful information source (3 ms)	
Trade training	1 (5.6)
Newspapers or television news	0 (0.0)
WorkSafe/WorkCover advertising	4 (22.2)
Information from trade associations or unions	0 (0.0)
From work health and safety training	8 (44.4)
From my boss	3 (16.7)
From co-workers	0 (0.0)
Other	2 (11.1)
Read a code of practice or other guidance on how to manage any work health and safety risks when unpacking containers	7 (33.3)
Which codes of guidance?[a]	
Safe Work Australia code or guidance	4 (19.1)
State or Territory WorkCover/WorkSafe code or guidance	3 (14.3)
Guidance produced by an industry association	0 (0.0)
Guidance produced by trade union	0 (0.0)
Other[b]	1 (4.8)

(a) Multiple responses were permitted
(b) WHS training
Note:
ms = missing observation(s)

The responses to the questions on risk perceptions are presented in Table 16. The responses to the question on the likelihood of exposure to chemical fumes when unpacking containers gave an arithmetic mean of 3.0 (SD 1.4) using a scale of 1 (very unlikely) to 5 (very likely). This mid-line result might mean that workers are generally unsure as to whether they may be exposed. When asked about how harmful exposures to fumes may be, a similar mid-line response was observed (arithmetic mean of 3.4; SD 1.0). When asked about the risks of harm from five other hazards, responses for each hazard were rated with arithmetic means equal or above 3.4. This may mean that these risks are of greater concern to workers than those from chemical fumes or that they are more generally understood. Workers rated working in areas with moving vehicles as the hazard with the greatest risk of harm.

Table 16. Perception of risk of exposure to chemical fumes in workers unpacking containers

Perceived risks of exposures to fumes	AM (SD)
Likelihood to be exposed to fumes when unpacking containers (n=12)[a]	3.0 (1.4)
Exposure to fumes is harmful to the worker's health (n=10)[b]	3.4 (1.0)
	n (%)
Able to protect oneself from fumes in containers	10 (47.6)
Other perceived risks of harm due to the following activities[c]	**AM (SD)**
Working at heights above 2 metres	3.4 (1.2)
Working with forklifts	3.8 (0.8)
Working with large machinery or plant, such as cranes or hoists	3.5 (1.3)
Lifting or moving heavy objects	3.7 (0.9)
Working in areas with moving vehicles	4.0 (0.8)

(a) Answers ranged from 1 (very unlikely) to 5 (very likely)
(b) Answers ranged from 1 (not very harmful) to 5 (extremely harmful/possibly fatal)
(c) Answers ranged from 1 (no risk or negligible risk) to 5 (extremely highly risk)
Notes:
AM = arithmetic mean
SD = standard deviation
Those who answered "don't know" were treated as missing

Identifying containers that may give off chemical fumes

The responses to the questions on how workers identify containers that may give off chemical fumes are presented in Table 17. To find out if a container might give off fumes, 38% of workers looked for warning notices on the container and 33% used their own experience to make this assessment. Approximately 24% of workers asked another worker, 24% asked their employer and 19% asked the owner/manager of the workplace. These figures suggest there is a lack of a definitive source of information in workplaces that helps workers identify containers that may give off chemical fumes. Nearly two thirds of workers thought that the presence of warning notices on the shipping container would be of most help to them in identifying containers that might give off chemical fumes. However, this figure may be inflated as where more than one response was provided the first response was used in the analyses. Workers also considered that the most help to them would be reliable information from the owner/manager of the workplace (14%), specific work health and safety training on unpacking shipping containers (14%) and access reliable information such as clearance certificates (10%). It was clear that most workers thought they had a limited ability to identify containers that may give off chemical fumes. Three-quarters of workers thought they either had limited ability to identify them or were not able to identify them. Only one worker reported being readily able to identify most containers that may give off fumes.

Table 17. Identifying shipping containers that may give off chemical fumes as answered by workers unpacking containers

Identification of shipping containers that may give off fumes	n (%)
Normal way of finding out if the container may give off chemical fumes?	
Look for warning notices on the container	8 (38.1)
Ask to see a clearance certificate or ask to see other information about the goods in the shipping container	2 (9.5)
Ask the owner/manager of the workplace	4 (19.1)
Ask my employer	5 (23.8)
Ask another worker	5 (23.8)
Use own experience	7 (33.3)
Not do anything	1 (4.8)
Other[a]	3 (14.3)
Most help to worker to identify a shipping container which may give off chemical fumes?[b]	
Warning notices on the shipping container	13 (61.9)
Reliable access to information about the contents of the shipping container, including clearance certificates	2 (9.5)
Reliable information from the owner/manager of the workplace	3 (14.3)
Specific work health and safety training on unpacking shipping containers	3 (14.3)
Other	0 (0.0)
Worker's ability to identify if a container may give off chemical fumes	
Readily identify most of them	1 (4.8)
Identify many of them	4 (19.0)
Limited ability to identify them	10 (47.6)
Not able to identify them	6 (28.6)

(a) Comments provided on run sheets

(b) Some selected more than 1 answer – the first answer was selected for analysis

Safety Precautions when unpacking containers

The response to the questions on how often workers unpacked shipping containers that may give off chemical fumes is presented in Table 18. Responses to questions about the safety precautions workers take when unpacking containers and factors that influence their decisions to follow safety precautions are also presented in Table 18; multiple responses were allowed for these questions.

The response to the question on how often workers unpacked shipping containers that may give off chemical fumes gave an arithmetic mean of 2.3 (SD 1.3) using a scale of 1 (rarely) to 5 (every day). This may be an under-estimation considering that many workers noted they had limited ability to identify fumigated containers (see above).

Before starting to unpack containers, slightly more than half (52.4%) of the respondents reported that they get instructions from their employer/manager, while a slightly lower percentage (38%) reported that they ensure that the container is in a designated area with good ventilation. About 28% checked to see if the container may give off fumes, while less than 10% set up barricades and placed warning signs around the entrance.

Before entering containers just over half (52.4%) the workers reported that they get instructions from their employer/manager while a slightly smaller percentage (43%) reported they opened the container taking care to avoid exposure to fumes before entering the container. Less than 10% of the respondents extracted fumes with natural ventilation for more than 12 hours, and one reported extracting fumes using mechanical equipment for more than 30 minutes. Fourteen per cent of respondents tested the air in the container using air testing equipment.

The vast majority (over 90%) of respondents used forklifts to unpack containers, often with other aids including pallet trolleys (29%), or trolley hoists or other lifting aids (14%).

Protection used when unpacking shipping containers showed a similar pattern to the previous questions, with the highest percentage of workers reporting they get instructions from their employer/manager (43%), and one-third using personal protective equipment (PPE; respiratory mask) for protection when unpacking shipping containers. Of those who reported the use of PPE, less than half (43%) reported they first obtain instructions from their managers prior to entering a container. Approximately one-quarter chose to partially unpack the shipping container and then vent and repeat until unpacking is complete. Fourteen per cent continually tested the air in the container using air testing equipment.

When asked about the provision of specific safety procedures for unpacking shipping containers, workers noted that their employers provide them with specific safety procedures most of the time. They also noted that the employer's safety procedures were followed most of the time. The 19 workers who noted they follow safety precautions were also asked to rate the importance of a number of predetermined factors on a scale of not important (1) to very important (5). The workers responded that awareness that containers give off fumes, training in unpacking shipping containers, having supervisors or bosses who ensure that safety procedures are followed, being able to protect themselves from fumes, and the provision of necessary safety equipment were all important. Fear of inspection and prosecution by work health and safety inspectors, media awareness campaigns and the involvement of unions were considered less important. The most important factor to most workers (57.9%) was awareness that containers may give off chemical fumes. However some workers provided more than one response to this item.

All workers were asked why they don't take safety precautions unpacking shipping containers, assuming that no worker would take them at all times. Initially workers (n=11) were asked to provide a rating for a number of predefined responses, but results indicated that either all of these items were of equal importance, or that this question was not able to discriminate between the 13 choices. Therefore halfway through the study this question was changed and newly recruited workers (n=10) were asked to indicate all factors that applied without providing a rating of its importance. The results provided in Table 18 summarise the responses of those 10 workers and showed that the most frequently cited factor for not taking safety precautions when unpacking shipping containers was not being aware that the container may give off chemical fumes (50%).

The following question was the same for all workers and asked for *the* most significant reason for not taking safety precautions. "Lack of training" was cited by 33% of respondents, followed by "lack of awareness that the container may give off chemical fumes" by 29%. One respondent cited co-workers not following safety precautions, and one respondent indicated that the necessary safety equipment was not provided. None cited the remaining listed reasons. The response to this question was somewhat surprising in that 33% cited lack of training as the reason for not taking safety precautions, despite earlier questionnaire responses indicating that 71% had received work health and safety training (Table 14), and that 93% of the 15 respondents to a following question reported that "reporting incidents" was covered in their work health and safety training (Table 14).

Table 18. Safety precautions when unpacking containers

Unpacking shipping containers	
	AM (SD)[a]
How often do workers unpack shipping containers that may give off chemical fumes?	2.3 (1.3)
First thing before start:[b]	**n (%)**
Check to see if container may give off fumes	6 (28.6)
Ensure container is in a designated area with good ventilation	8 (38.1)
Set up barricades and place warning signs around entrance	2 (9.5)
Get instructions from employer/manager	11 (52.4)
Other	1 (4.8)
Before entering shipping containers: [b]	**n (%)**
Open container taking care to avoid exposures to fumes	9 (42.9)
Extract fumes using mechanical equipment >30 mins	1 (4.8)
Extract fumes using natural ventilation for >12 hours	2 (9.5)
Test air in container using air testing equipment	3 (14.3)
Get instructions from my employer/manager	11 (52.4)
Other	1 (4.8)
Tools or equipment used to unpack shipping containers: [b]	**n (%)**
Forklifts	19 (90.5)
Pallet trolleys	6 (28.6)
Trolley hoists	1 (4.8)
Other lifting aids	2 (9.5)
None	1 (4.8)
Protection used when unpacking shipping containers: [b]	**n (%)**
Wear PPE	7 (33.3)
Partially unpack shipping container and then vent and repeat until unpacking is completed	5 (23.8)
Continually test the air in the container using air testing equipment	3 (14.3)
Ensure rescue procedures are in place	0 (0.0)
Get instructions from my employer/manager	9 (42.9)
Other	2 (9.5)
	AM (SD)[c]
How often does the employer provide specific safety procedures when unpacking shipping containers?	4.1 (1.5)
How often are employer's safety procedures followed?	4.5 (1.0)
For those workers (n=19) who generally follow safety procedures, how important are the following factors:	**AM (SD)[d]**
Awareness that container may give off fumes	4.3 (1.1)
Media awareness campaigns	2.9 (1.7)
Training in procedures for unpacking shipping containers	4.6 (0.9)
Supervisor/boss ensures that safety procedures are followed	4.3 (1.2)
Co-workers all wear protection and follow the safety rules	4.1 (1.4)
Being able to protect oneself from exposure to fumes	4.5 (0.8)

Unpacking shipping containers	
Necessary safety equipment is provided	4.4 (1.1)
Involvement of unions on the site	2.9 (1.8)
Fear of inspection and prosecution by work health and safety inspectors	3.5 (1.4)
For those workers (n=19) who generally follow safety procedures, which factors listed below are most important to the worker: [b]	**n (%)**
Awareness that container may give off fumes	11 (57.9)
Media awareness campaigns	0 (0.0)
Training in procedures for unpacking shipping containers	7 (36.8)
Supervisor/boss ensures that safety procedures are followed	2 (10.5)
Co-workers all wear protection and follow the safety rules	2 (10.5)
Being able to protect oneself from exposure to fumes	5 (26.3)
Necessary safety equipment is provided	2 (10.5)
Involvement of unions on the site	0 (0.0)
Fear of inspection and prosecution by work health and safety inspectors	1 (5.3)
None	0 (0.0)
Why are safety precautions not taken when unpacking containers? (ms 11)	**n (%)**
Not aware that container may give off chemical fumes	5 (50.0)
No training for unpacking shipping containers	0 (0.0)
Supervisor/boss doesn’t enforce safety procedures	1 (10.0)
Co-workers don’t follow safety procedures	0 (0.0)
Not much risk to myself from exposure to fumes	0 (0.0)
I am prepared to take the risk	0 (0.0)
the safety procedures are not very effective	0 (0.0)
Not able to take necessary safety precautions	1 (10.0)
The necessary safety equipment is not provided	1 (10.0)
Wearing protective equipment is uncomfortable or too difficult	0 (0.0)
It takes too long to follow the safety procedures	0 (0.0)
It is too expensive to do everything by the book	0 (0.0)
There is little chance of being detected by work health and safety Inspectors	0 (0.0)
Don’t know	4 (40.0)
Other	0 (0.0)
Which of the following reasons is the most significant for not taking safety precautions? (3 ms)	**n (%)**
Not aware that container may give off chemical fumes	6 (28.6)
No training for unpacking shipping containers	7 (33.3)
Supervisor/boss doesn’t enforce safety procedures	0 (0.0)
Co-workers don’t follow safety procedures	1 (4.8)
Not much risk to myself from exposure to fumes	0 (0.0)
I am prepared to take the risk	0 (0.0)
The safety procedures are not very effective	0 (0.0)
Not able to take necessary safety precautions	0 (0.0)

Unpacking shipping containers	
The necessary safety equipment is not provided	1 (4.8)
Wearing protective equipment is uncomfortable or too difficult	0 (0.0)
It takes too long to follow the safety procedures	0 (0.0)
It is too expensive to do everything by the book	0 (0.0)
There is little chance of being detected by work health and safety Inspectors	0 (0.0)
Don't know	3 (14.3)
Other	1 (4.8)

(a) Answers ranged from 1 (rarely) to 5 (every day)
(b) Multiple answers were permitted
(c) Answers ranged from 1 (never) to 5 (always)
(d) Answers ranged from 1 (not important) to 5 (very important)

Notes:

AM = arithmetic mean
SD=standard Deviation
ms = missing observation(s)
Those who answered "don't know" for questions with a rating scale were treated as missing

3.3 Observations made during field work campaign

Discussions with managers and workers

During the course of the study experienced managers (n=5) and workers (n=15) with extensive knowledge of the logistics sector were interviewed in an informal and unstructured manner. In particular, issues relating to the unloading, distribution and fumigation of shipping containers were discussed. These discussions are summarised below:

1. Fumigation of containers onshore in Australia requires that levels of methyl bromide must be below the 5 ppm level before the container can be released. Several persons commented that commercial pressures mean that this standard is not always followed though the situation is better than it had been previously.
2. Even when the container air after onshore fumigation is below 5 ppm for methyl bromide the levels in the product boxes within the container may be much higher. This is seen as a particular risk for workers who open these boxes. The current study has demonstrated this potential risk for a box containing imported timber from Vietnam which was fumigated onshore. An extremely high level of methyl bromide was measured (186 ppm) within the box after it had been removed from the shipping container.
3. Workers being paid on a "piece rate" basis for unloading containers felt as though they had no option but to continue unloading even if a problem was discovered. Some workers felt that if they did complain they simply would not be asked to come back.
4. Containers that had been fumigated offshore often have no placards stating they are fumigated.
5. No systematic assessment of containers took place prior to entry.
6. The use of refrigerated containers for general use (see Photograph 3) could cause problems. Some residual chemicals such as methyl bromide are heavier than air and there is a possibility that they may be trapped in pockets in the floor rails underneath boxes.
7. Some commented that containers may be fumigated offshore but that this is not declared on any paper work because it is cheaper to ship 'unfumigated' shipping

containers. This practice may result in a shipping container being fumigated twice – once offshore and then in Australia – potentially increasing the levels of fumigants in shipping containers or the chance those fumigants will be used at high levels. Where fumigation does occur offshore uncertainty exists as to how fumigations have been carried out. Goods may be fumigated prior to being placed in the shipping container or the entire consignment may be fumigated within the shipping container.

Photograph 3. A refrigerated container used for transporting general goods

The channels in the refrigerated container allow cool air to circulate but can trap pockets of residual chemicals.

Observations of work practices

The most important observations related to potential hazards made by field staff during the field work campaign are summarised below.

PID use to identify residual chemicals

Although a PID will not be suitable on its own when a "soup" of compounds may be present in shipping containers, it provides some indication of a potential hazardous situation. All participating businesses made a PID available for workers to use prior to entering a container. However, in nearly all cases workers did not use a PID routinely to measure VOC levels prior to entering a container. Those workers who used a PID often wore it in such a way that the functioning of the PID was impaired—i.e. the PID was worn under protective clothing.

Thermal Environment

High temperatures were observed sometimes in excess of 45°C. High temperatures and a lack of ventilation combined with the high work rate encouraged by contractual arrangements places significant thermal stress on workers unpacking shipping containers. Anecdotally workers noted that higher temperatures during summer produced higher levels of fumes/smells inside shipping containers. This could not be confirmed in the current study as measurements were not conducted over warmer and colder months.

Falling goods

Securing container doors with a short rope that is long enough to see if the goods have shifted when the doors are partially opened is recommended in some guidance material (WorkSafe Victoria 2010). An easier to use solution is to regularly use a strap as shown in

Photograph 4 rather than a rope. This is a low cost solution that was employed by one of the businesses that participated in this study.

Photograph 4. A safety strap is used to prevent the cargo from forcing open the container door and goods falling on workers

Manual Handling

Packing and unpacking shipping containers poses long established and recognised manual handling risks, with the potential to cause musculoskeletal injuries or disease. The following examples of high risk manual handling activities were observed: frequent lifting of items that were above shoulder height or below knee height, lifting and carrying heavy items, carrying over long distances, and awkward postures for long periods.

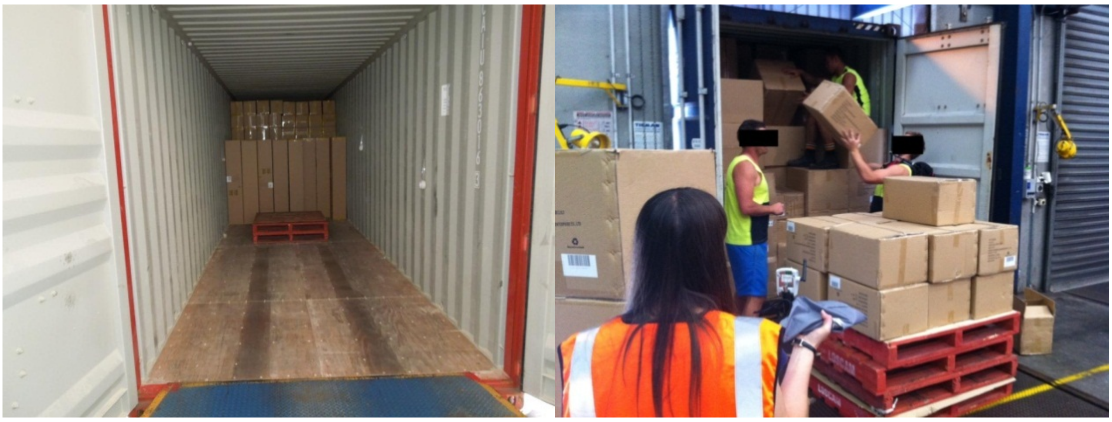
The risks posed by these activities can be eliminated or significantly reduced by using mechanical loading and unloading systems and by handling goods on slip-sheets or pallets. Of the control practices recommended, only forklifts were used. Workers were not observed using platform ladders to access goods at height and they were not observed using pallet jacks, trolleys or adjustable conveyors to ensure goods were handled between knee and shoulder height. Most workplaces used job rotation where possible to minimise exposure to manual handling risks.

The majority of containers that workers unpacked were not palletised (see Photograph 5). The decision to remove pallets from containers appears to have been driven by two factors:

1. removing the need to fumigate shipping containers where only the pallets and not the goods require fumigation, and
2. enabling more products to be loaded into shipping containers where space is not taken up by pallets.

When the container loads were not palletised, the containers were unloaded by one or more workers (see Photograph 5). Workers typically used a forklift to place a pallet in or near the shipping container and subsequently manually loaded boxes onto the pallet. At some workplaces all workers had to remain outside the shipping container when the forklift was driven into it, in others the workers were permitted to remain inside the shipping container.

Generally, these practices resulted in loads that weighed up to 40 kg being lifted above shoulder height or below knee height.



Photograph 5. Unpacking shipping containers

Left: A non-palletised container. *Right:* Workers unloading a non-palletised container

Pedestrian and mobile plant separation

All participating businesses had clearly defined areas for unloading shipping containers with pedestrian walkways clearly marked and observed. All shipping containers were placed well away from power lines. While the guidance note (WorkSafe Victoria 2010) recommends that workers who frequently unpack shipping containers should wear location sensors this practice was not observed.

Seatbelts

Seatbelts were fitted to all forklifts used at participating businesses. Workers who drove the forklift all the time or for extended periods wore the seatbelts. Workers who changed tasks regularly, e.g. getting on and off the forklift to load pallets, did not. On one occasion the seat belt was clipped in to circumvent an interlock but was sat on rather than worn by the forklift driver.

4. Discussion

This study provides preliminary data about personal worker (i.e. breathing zone) exposure to residual chemicals when shipping containers are inspected and/or unpacked. Real-time monitoring techniques and remote grab sampling (VEM and RAGS) were employed during the unloading of 76 shipping containers. A small number of additional samples were also collected and analysed including: time-weighted average exposures of persons unloading shipping containers; general workplace air where unloaded container contents are stored; air within boxes containing fumigated materials; and emissions from a single odorous material.

In addition workers and students who unload shipping containers ("exposed workers") completed a health questionnaire. Results were compared with workers and students from the same warehouse or training institute not involved in unloading shipping containers ("unexposed workers"). A risk management survey was completed by exposed workers and students. Work practices used during the unpacking of shipping containers were observed to help identify related work health and safety issues.

Residual chemicals were detected in "peak" personal samples taken in 74 of the 76 containers (97.4%).In eight per cent of the containers air samples exceeded the Australian WES for one of the residual chemicals tested (i.e. chloropicrin, 5.3%; and formaldehyde, 2.6%). In one container the air sample reached the applicable Australian STEL for formaldehyde and in another container the inferred STEL of 3 times the TWA level for chloropicrin was exceeded. In one-third of all containers at least one of the tested residual chemicals in personal air samples exceeded the Dutch MAC, an occupational exposure limit previously used in the literature. In the 12 TWA samples taken the levels of residual chemicals were generally low, and in no case was an Australian 8 hour TWA WES or STEL exceeded. The MAC value was exceeded for formaldehyde in one sample. Very high levels of chloropicrin and methyl bromide were found in the few product boxes containing wooden outdoor furniture. VOC levels in product boxes with EVA foam mats were also very high, but the chemicals that contributed to these high levels were not identified.

Exposed workers reported symptoms of memory loss, irritation and asthma more frequently than non-exposed workers, but due to the low number of workers surveyed and the lack of control for confounding these data should be considered inconclusive. Most workers had received work health and safety training, but there was still a large degree of uncertainty regarding the risks associated with fumigated containers, their ability to identify fumigated containers, and appropriate safety precautions were not always taken. Results of the study will be discussed in more detail below.

4.1 Exposure measurements

Personal "peak" exposures

Trace levels of residual chemicals were identified in almost all personal "peak" samples. The results, in terms of compounds detected (independent of concentration), are generally consistent with those reported for container air from containers imported into the Netherlands (Knol-de Vos 2003) and for containers imported into Germany (Baur et al. 2010a). There are some notable differences: methyl bromide was detected at a higher frequency in shipping containers imported to Australia in this study, while benzene and formaldehyde were more frequently detected in shipping containers imported to the EU. The reasons are not clear, but it may be related to differences in container contents or country of origin. A comparison with a previous study conducted in Australia (Frost 2010) was not possible as comparable data were not available for that study.

The focus of this study was on short-term (20–30 seconds) peak exposures that allow comparisons to be made with STEL or ceiling levels, and which may aid the development of effective interventions to reduce (peak) exposure levels. In this study only one container air sample reached the applicable Australian STEL for formaldehyde, while in another container the inferred STEL of three times the TWA level for chloropicrin was exceeded. A previous study by Australian Customs (Frost 2010) did not report the proportion of containers with levels above the STEL. Therefore a comparison with this study could not be made.

Although eight hour TWA occupational exposure standards are generally not considered appropriate for evaluating a 20–30 second exposure due to the different averaging times these have frequently been used in previous studies of residual chemicals in shipping containers as a comparison metric. For the purpose of comparing the results from this study with those of other studies the same eight hour TWA standards have been used. In eight per cent of the containers measured in this study personal air samples exceeded the Australian WES for one of the residual chemicals tested. This is lower than was previously found in a much larger study by Australian Customs (Frost 2010) which showed that 17% of all tested containers (12% of the containers in Melbourne and 22% of the containers in Brisbane) had fumigant levels exceeding the WES. In the Customs study the most common residual chemicals exceeding the WES were formaldehyde and 1,2-dibromoethane, followed by chloropicrin and methyl bromide. In the current study only formaldehyde and chloropicrin exceeded the WES in a small proportion of all containers (chloropicrin, 5.2%; and formaldehyde, 2.6%).

Using Dutch MAC values (workplace exposure standards previously used in the literature) as a comparison, it was shown that in 32.9% of all containers personal "peak" samples exceeded the MAC for at least one of the tested chemicals; 11.8% of the containers contained levels above the MAC for two or more of these chemicals. The two most common residual chemicals exceeding the MAC were formaldehyde (19.7%) and methyl bromide (18.4%). These results are reasonably consistent with a previous study conducted in the Netherlands showing that in the period 2004 to 2006 almost 25% of shipping containers contained residual chemicals at levels above the MAC (de Groot 2007). A previous study conducted in the Netherlands, however, showed that residual chemicals exceeded the MAC in only 5% of the containers (Knol-de Vos 2003).

Previous studies including the Australian Customs study and the studies in Europe did not involve personal sampling but instead relied on air samples taken from a sealed container prior to or directly after opening the container which complicate a direct comparison. This is an important difference, particularly since containers evaluated in the current study were often open and venting to the warehouse for significant periods of time prior to unloading. This would most likely have resulted in significantly lower concentrations although this could not be confirmed.

In the current study multiple samples from the same container were collected for at least a proportion of all containers. Using the highest concentration measured (as opposed to the mean) did not significantly change the results suggesting that intra variability of residual chemical concentrations could not explain the lower levels of residual chemicals in the current study compared to the previous Australian Customs study (Frost 2010).

Containers of outdoor wooden furniture generally had the highest levels of residual chemicals, particularly fumigants. This is consistent with a study of 2113 containers in Hamburg (Baur et al. 2010a) which found that containers with furniture/household goods and containers with foodstuffs and natural products were consistently more likely to have elevated levels of residual chemicals. The higher level of residual chemicals most likely reflects the requirement for fumigation of wooden products. The other containers did not include wooden products or wooden pallets and neither the products nor bunting materials if present appear to have required fumigation. It was not possible to verify this as no information could be obtained about whether containers had been fumigated and if so when. In fact of all containers assessed in this study only one had an external notice identifying the container as having been fumigated. Given that trace levels of residual chemicals were detected in most samples, the possibility that fumigation had been carried out—combined with appropriate venting prior to shipping, lengthy transit times, and good work practices in participating businesses—cannot be ruled out. Interestingly, questionnaire responses by workers indicated that they were equally unsure of the fumigation status of containers they were unloading.

Personal "peak" exposures measurements were based on samples from workers unloading 76 containers in Melbourne and Brisbane. The businesses recruited and containers sampled consisted of a "convenience sample" and are therefore unlikely to be representative of the seven million containers passing through Australian ports each year. In particular, only six businesses participated in the study and the products they imported were generally not packed on pallets or other materials requiring fumigation. The results from this study therefore, should not be considered representative for all commodities routinely freighted to Australia in shipping containers. This may also in part explain the differences between the current study and the previous study conducted in Australia involving many more containers (Frost 2010).

Due to the delay between sample collection and analysis, there was the potential for the level of certain chemicals to have reduced inside the Tedlar or Kynar sampling bags. Based on the results of a validation experiment (Appendix 1) analytical results were adjusted for most chemicals tested. Chemicals not validated included styrene, 1,2 dibromoethane and ammonia and no correction factors were applied for these chemicals which may have resulted in an overestimation of the exposure levels. However, for styrene and ammonia the unadjusted levels never exceeded the WES or MAC, therefore any lack of adjustment could not have affected the overall estimated proportion of measurements exceeding the WES or MAC. Unadjusted 1,2 dibromoethane levels also did not exceed the WES, but five measurements (6.6%, Table 4) exceeded the MAC which may have affected the overall results involving comparisons against the MAC. However, 1,2 dibromoethane is very stable with a half-life of 40–70 days and the effect of the delay between sampling and analysis is therefore expected to be small. Nevertheless a more significant decline in concentration cannot be excluded. For any future studies the use of stainless steel canisters for sample collection and minimising the time between sampling and laboratory analyses to a maximum of 12 hours is recommended. This should minimise variance in exposure assessment due to sampling limitations.

Exposures during 2–3 hour shifts

Since the focus of this study was on peak exposures involving the collection of short-term (20–30 seconds) grab samples it was not clear whether full eight hour shift exposures occurred at or above applicable workplace standards. To assess this 12 two–three hour TWA "shift samples" were collected coinciding with the average time it took workers to unload one container. None of these exceeded the WES and only one exceeded the MAC. This suggests that eight hour exposures may be significantly lower compared to exposures measured using 20–30 second grab sampling. This is a logical finding as TWA sampling will include those periods of time with lower or no exposure to residual chemicals when workers are not inside shipping containers or near products being unloaded. However only 12 shift samples were collected and none involved workers unloading containers with wooden outdoor furniture which were shown to have the highest levels of fumigants. There remains the possibility that had sampling been conducted in containers known to be fumigated, such as the wooden furniture imported from Asia, exposures to fumigants in excess of applicable WES concentrations might have been found.

Organisations that participated in this study used mainly contracted workers to unload containers or employed a mix of contracted and full time workers. This may mean that some workers did additional shifts at other locations that may add to their overall exposure burden which was not taken into account in this study. At this stage it remains largely unclear what typical eight hour TWA exposure levels are for workers handling shipping containers in Australia. A larger study involving more extensive full-shift sampling of a wider range of containers is, therefore, recommended. If this showed that personal shift measurements regularly exceed the WES for a specific subset of containers such as those with wooden furniture or other goods requiring fumigation then a more targeted study could be conducted to identify peak exposures aimed at developing effective intervention strategies.

Area sampling

PID surveys of warehouse storage areas of contents unloaded from containers did not detect residual chemicals. Further investigation of this issue may not be warranted.

Product samples

Air within boxes containing furniture from Vietnam and fumigated either in Australia or Vietnam contained methyl bromide at concentrations of 186 ppm (Australia fumigated) and 14 ppm (Vietnam fumigated). Chloropicrin at a concentration of five ppm was also identified in the boxes fumigated in Vietnam, exceeding the NIOSH IDLH level of 2 ppm. Other residual chemicals were measured in lower concentrations. These results are based on only two samples and they are source concentrations, i.e. no attempt was made to measure personal exposure during opening or handling of these boxes. Nonetheless these results show the potential for high exposures for workers and consumers unpacking cardboard boxes. Further research into this issue is recommended.

Boxes with EVA foam mats with pronounced emission odours were analysed in response to worker concerns. There had also been previous concerns over high formamide levels in these products leading to product recalls. PID measurements showed very high exposure levels of up to 8,000 ppm; however, subsequent SIFT-MS and GCMS analyses were inconclusive and only showed moderately elevated levels for ammonia which in itself could not explain the high PID readings. The reasons for those high PID readings therefore remain unclear and require further study. Based on workers' concerns and the high PID readings additional preventive measures are recommended.

4.2 Surveys

Health survey

The Health survey was completed by 22 “exposed” and 61 “non-exposed” workers. Several respondents were part-time TAFE students. These small numbers do not allow for detailed statistical analysis or for adjustments for confounding or effect modification to be assessed. A large number of symptoms were also assessed so based on chance alone some would be expected to be different between both groups. Therefore differences observed in this study may be due to confounding and/or simply chance. Results should be considered indicative only and results cannot be generalised to industry or occupational groups.

Generally most differences in the prevalence of symptoms were small between “exposed” and “non-exposed” workers. Nonetheless we found that “exposed” workers more frequently reported symptoms suggestive of memory loss and respiratory irritation. Although fumigants and other volatile chemicals detected in shipping containers have toxic properties which may cause neurotoxic symptoms including memory loss and respiratory irritations, these finding should be considered inconclusive due to the limitations described above. The number of years that workers had symptoms suggestive of memory loss ranged from eight to 10 years which is longer than the majority of workers had worked in the current trade/occupation. This would argue against an occupational cause although it cannot be excluded.

In addition to sample size limitations, “exposed” and “non-exposed” workers were selected from different sources including TAFE students. To assess the extent of any potential bias this may have caused the analyses were repeated excluding TAFE students. These analyses showed highly comparable results suggesting that any bias due to this issue is small.

Despite the limitations of the study, the results indicate that further work to validly assess the risk of neurotoxic and respiratory symptoms in a larger group of workers is warranted.

Hazard survey

Seventy-one per cent of the 21 respondents had completed training related to unpacking shipping containers and 60% reported that risks of exposures to chemical fumes were covered in their work health and safety training. Also 33% had read a code of practice or other guidance on how to manage any work health and safety risks when unpacking containers. Nonetheless, none claimed to know a lot about the risks of chemical fumes in containers, although 67% noted they knew a little with just over half (57%) noting this knowledge was obtained through work health and safety training. This suggests that although workers had received training, the specific training related to residual chemicals may not always have been adequate.

In general, workers appeared unsure about their exposures to residual chemicals in containers, and 76% of respondents reported limited or no ability to identify containers giving off chemical fumes. This is consistent with observations made by field staff which found only one of the containers included in the study to have a notice stating that the container had been fumigated. Almost two-thirds of workers stated that warning labels on the shipping container would be of most help in identifying containers that give off chemical fumes. Consistent enforcement of existing requirements to label fumigated shipping containers is recommended. However non-compliance has been noted in previous international studies.

Thirty-eight per cent of the respondents reported that they ensured that the container is in a designated area with good ventilation and 43% reported that they opened the container taking care to avoid exposure to fumes before entering the container. Less than 10% extracted fumes with natural ventilation for more than 12 hours, and only one worker reported extracting fumes using mechanical equipment for more than 30 minutes. Only 14% of respondents tested the air in the container using air testing equipment and only about one-third of respondents used techniques for minimising exposure. This suggests that routine use of safety precautions is not applied by many of the workers and there is therefore significant potential for improvement.

The most significant reason for not taking safety precautions included lack of training (33%) and lack of awareness that the container may give off chemical fumes (29%). This confirms earlier conclusions that training may not have been adequate and that there is a clear need for improved signage on containers and/or for the information regarding fumigation in the supporting documents to be clearly communicated to supervisors and staff.

4.3 Workplace observations

Hazard identification

Shipping containers that have been fumigated are required to be labelled and declared in accordance with the International Maritime Dangerous Goods Code (International Maritime Organization 2010). As noted above the shipping containers observed in this study were often not labelled as being fumigated. The absence of labelling can’t be taken to mean fumigants are not present. In fact anecdotal evidence from talking to experienced operators in this sector suggests that containers are often fumigated but not declared to lower the cost of transportation. Workers who unpack shipping containers may not be able to take appropriate action to prevent exposures. This was demonstrated by survey results as discussed above.

As shown in this study shipping containers may also contain products that off-gas other hazardous chemicals, such as formaldehyde. There is no requirement to label these containers. This is exacerbated in workplaces where workers do not use PIDs to test shipping containers prior to entering them, as is often the case, and rely on olfactory senses to detect residual chemicals.

As noted above, businesses and their workers will benefit from the consistent enforcement of existing requirements to label fumigated shipping containers and the development of and/or better training in the use of, simple, reliable, cost-effective residual gas detection equipment.

Work practices

Containers were often left to ventilate naturally. For those containers with known high levels of fumigants, natural ventilation may require supplementation with forced ventilation to reduce residual chemicals to acceptable concentrations for unloading. Industry representatives expressed concern that ventilation systems extracting fumigants from containers were not effective because levels of fumigants within containers simply rose again after ventilation ended and the containers were closed up. To avoid this happening WorkSafe Victoria recommends repeat venting until unpacking is completed (WorkSafe Victoria 2009) but this recommendation is only given for containers that are tightly packed. In addition to this approach it may be useful to set a time limit (e.g. 2 hours) after which unloading should be stopped and the container would have to be ventilated again.

PIDs were sometimes worn by workers but were often worn in such a way that the functioning of the PID was impaired, for example, the PID was worn under protective clothing. Several organisations commented that while they had PIDs available, the instruments had given so many false responses or non-specific responses that they were now ignored. They acknowledged that this was not ideal but could see no other cost effective solutions. This has resulted in containers not being assessed prior to entry and a reliance on odours being detected by workers as a warning sign. These odours may be from products rather than fumigants. Some residual chemicals such as phosphine are not easily detectable by odour, even well above the workplace exposure standard. Workers may therefore have a false sense of security regarding fumigant exposure.

The comments by workers that the instrument had given so many false responses appear to contradict the observations of this study that showed no peak exposures using a PID. This may be due to the current study not having measured a representative sample of containers. Similarly, the observations of workers and managers may be related to very specific situations and/or time periods not included in the current study. PIDs may also produce false positives due to cross-sensitivities.

Discussions with managers and workers suggested that no systematic assessment of containers took place prior to entry by workers. In some instances this is indicative of the relationship between the overseas supplier and the business receiving the container shipment. In these cases the business knows what to expect for each specific shipment and it does not expect that the container will be hazardous and assumes the container is safe as it has not been fumigated. In reality, there is no guarantee that this is the case.

Interestingly, the results of the Hazard survey suggest that at least half the workers get safety instructions from their employer/manager before entering and/or unpacking containers and 43% reported that they opened containers taking care to avoid exposure to fumes before entering the container. This appears inconsistent with the suggestions that no systematic assessment takes place prior to entry. The reasons for these inconsistent findings are not clear but could be due to workers providing desirable answers in the written survey, or the fact that not all workers participating in the unstructured interviews participated in the written survey and vice versa.

Other hazards

In addition to hazards associated with fumigants and other residual chemicals there are other hazards associated with entering shipping containers. One hazard is the risk of the worker being struck by the doors where containers have been overfilled or the cargo has shifted. A simple measure to prevent this is to fix a safety strap to both doors. This is currently used in one high volume depot and is recommended to be adopted elsewhere as a low cost intervention.

No evidence was observed of lifting devices other than forklifts being used to reduce manual handling risk while unloading containers. Given the nature of the contractual arrangements where speed of unloading is paramount this is perhaps not surprising. Examples of current practices such as lifting heavy 40 kg boxes, hand lifting 25 kg boxes above shoulder height or below knee height more than once every five minutes are likely to lead to injury. Appropriate preventive measures are therefore required.

4.4 Conclusions and suggestions for future work

In conclusion this study, as well as previous studies, demonstrates the potential for workers handling shipping containers to be exposed to residual chemicals. Because of the limited scope of this study however, it is not clear whether full eight hour shift exposures occur at levels at or above applicable workplace standards and/or occur at levels that may cause adverse health outcomes.

Researchers anticipated that peak exposure levels would be associated with specific tasks or activities. However, this was not observed when VEM equipment was used.

This study showed very high levels of fumigants present in the very small sample of product boxes tested. This indicates the potential for high exposures to these substances for workers and consumers unpacking product boxes.

The Health survey found that exposed workers reported symptoms of memory loss, irritation and asthma more frequently than non-exposed workers. Due to the low number of workers surveyed and the lack of control for confounding these data should be considered inconclusive.

Although most workers had received work health and safety training there was still a large degree of uncertainty regarding the risks associated with fumigated containers and their ability to identify fumigated containers. Also safety precautions were often not taken by many workers.

Key suggestions for future work

Based on the study results the following research objectives and methods are suggested:

- To conduct a larger study involving more extensive full-shift personal sampling of workers unpacking a wider and more representative range of containers. This should be followed by a more targeted study to identify peak exposures in any subsets of containers associated with high personal exposure levels. It is not recommended to conduct more sampling in warehouse storage areas.
- To conduct a larger study to assess personal exposure levels of workers and consumers opening “high risk” product boxes.
- To use stainless steel canisters for sample collection in any future exposure studies.
- To minimise the time between sampling and analyses to a maximum of 12 hours.
- To conduct further measurements to identify the specific chemicals associated with the high PID readings of air in boxes with EVA foam mats and to measure personal workers’ exposures to these chemicals. In the absence of further measurements it is

recommended that additional preventive measures, i.e. consistent use of PIDs and respiratory protection if required, are used in those workplaces where workers unload EVA foam mats.

- To conduct a health survey focussing on neurotoxic and respiratory symptoms in a larger group of workers inspecting or unpacking shipping containers. This will allow epidemiological analyses to be conducted with appropriate control for potential confounders. A population sample of 400 exposed and 200 unexposed would provide sufficient power to provide conclusive results.

While this study might present indicative results, it has highlighted some potential work health and safety issues. To ensure that workers who unpack shipping containers are adequately protected against risks associated with residual chemicals and manual tasks, it is suggested that work health and safety policy makers and practitioners:

- consistently enforce:
    - existing requirements to label fumigated shipping containers, and
    - health and safety guidelines for inspecting and unpacking shipping containers, which include using gas monitoring devices to test the air in shipping containers prior to and during unpacking operations
- develop guidance that:
    - encourages routine repeat venting until unpacking is completed for tightly packed containers as per existing WorkSafe Victoria guidelines (WorkSafe Victoria 2009), and
    - sets a time limit (e.g. two hours) after which unpacking should be stopped so that container air can be tested and ventilated again where required
- improve health and safety training for managers and workers inspecting and unloading containers, and
- recommend the use of safety straps when initially opening shipping containers to prevent shifted contents from forcing doors open and contents falling on workers.

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Appendix 1: Stability of VOCs in Sample Bags

Introduction

This report presents the measured concentration stability of a number of fumigant and other compounds in sample bags over an approximately two day time frame. The results from three different types of sample bags are reported:

- 1 L SKC, Tedlar
- 0.5 L Plastic Film Enterprises, Kynar
- 0.5 L Plastic Film Enterprises, Premium Kynar.

The effects of concentration and humidity on the stability of the measured concentrations are also presented.

Conclusions

- The concentration and humidity of the samples studied had no effect on the stability of measured concentrations for any of the compounds tested.
- The concentration stability of compounds in sample bags varies greatly, depending on the nature of the compounds:
    - The concentration of ethene, isobutane and phosphine remained stable throughout the ~2 day study.
    - The concentration of methyl bromide, dichloroethane, ethylene oxide, octafluorotoluene, hexafluorobenzene, tetrafluorobenzene, xylene, toluene and benzene declined by <70% over the ~2 day period.
    - The concentration of hydrogen cyanide and formaldehyde declined more quickly, dropping by 50% within half a day and by >80% after ~2 days. Based on the rapid transfer of water through these bags, the primary loss mechanism for these two (small-molecule) compounds is thought to be permeation through the bag walls.
- There was little difference in performance between Kynar and Premium Kynar.
- Tedlar bags vastly outperformed the Kynar bags for the storage of the majority of compounds tested. In no cases did the Kynar bags out-perform the Tedlar bags.
- All three bags tested were highly permeable to water; the humidity converged to ambient humidity (whether initially more or less humid than ambient) with ~1.5 hours.

Method

The 1 L Tedlar sample bags tested had a larger internal surface area (~660 cm^2) than the 500 mL Kynar bags (~570 cm^2) so to keep the surface-area-to-volume ratio constant for both samples, the Kynar bags were filled to 500 mL while the Tedlar bags were filled to 600 mL.

Standard concentrations of the following compounds were provided using the Syft Calibration Rig.

Compound	Source	Concentration	Group*
Methyl bromide	Permeation tube	5.7 ppm	1
Dichloroethane	Permeation tube	2.9 ppm	2
Ethylene oxide	Permeation tube	8.7 ppm	2
Hydrogen cyanide	Permeation tube	13 ppm	2
Chloropicrin	Permeation tube	0.9 ppm	3
Formaldehyde	Permeation tube	10 ppm	4
Phosphine	Gas standard	5.0 ppm	5
Benzene	Gas standard	2.1 ppm	6
Toluene	Gas standard	2.1 ppm	6
Xylene	Gas standard	2.0 ppm	6
Ethene	Gas Standard	2.0 ppm	6
Isobutane	Gas Standard	2.0 ppm	6
Tetrafluorobenzene	Gas Standard	2.1 ppm	6
Hexafluorobenzene	Gas Standard	2.1 ppm	6
Octafluorotoluene	Gas Standard	2.1 ppm	6

* Compounds with the same group number were measured simultaneously from the same sample bags. These compounds were either in the same gas standard (Group 6) or were run concurrently from the permeation oven (Group 2).

Three bags each of Tedlar, Kynar and Premium Kynar were prepared for each of these compounds. The first was prepared at the concentration stated in the above table with a balance gas of dry nitrogen, the second was a 10-fold dilution in dry nitrogen, and the third was a 10-fold dilution at an effective 25 C relative humidity of ~120%. The samples were measured immediately and compared to the measured concentration delivered directly from the Calibration Rig. Further measurements, each preceded by an Instrument Validation, were carried out for each sample bag over a period of ~2 days.

The total sample consumed from each bag during the course of all measurements was ~110 mL.

Results and Discussion

An examination of the water cluster products of H3O+ for all measurements revealed that for all three types of bags the humidity in the bag changed very rapidly. Whether the initial humidity was above or below ambient, for all three bags the sample humidity converged on the ambient humidity in ~1.5 hours!

A comparison of the measured concentrations for the concentrated samples with the dry and humid dilutions did not reveal any effects that could be attributed to either concentration or sample humidity. Of course for compounds that have an attenuated measurement at high humidity (such as methyl bromide and formaldehyde), the measured concentration in the bag increased as the humidity trended towards the ambient humidity. But apart from this expected effect, there were no clear signs that the sample concentration or humidity had an effect on the rate of loss of gas-phase compounds in the sample bags.

Below are figures showing the time stability of concentration measurements for the 15 compounds studied. In the labels of each graph, “T” indicates a Tedlar bag, “K” the standard Kynar bag, and “PK” the Premium Kynar bag. In each case the black diamond indicates the concentration of analyte measured directly from the Calibration Rig and the concentrations have been normalised to the average of the T, K and PK measurements of the first measurement.[1]

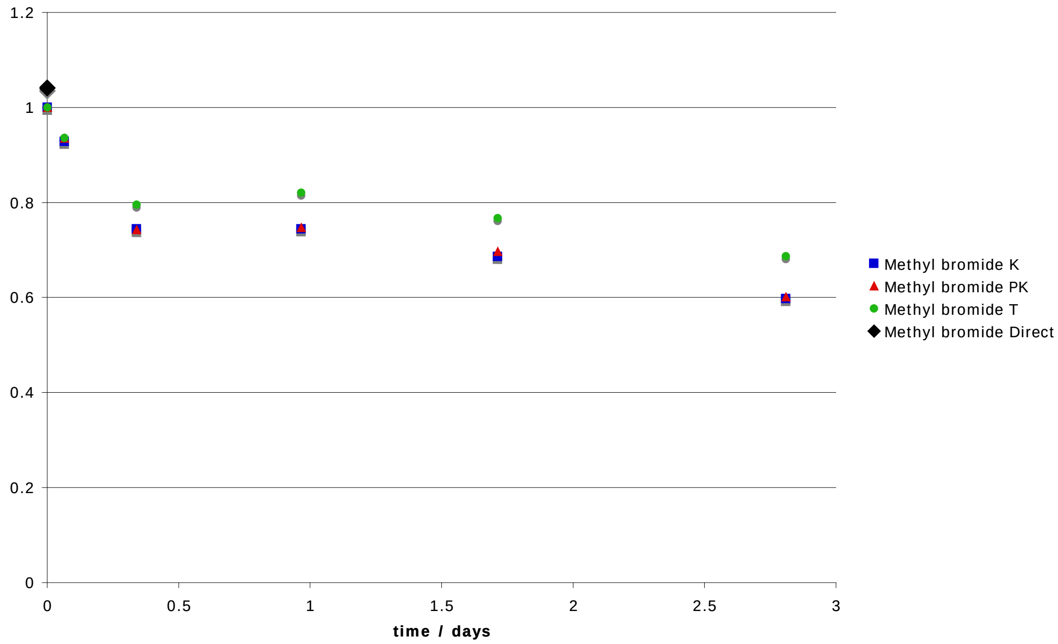
It is apparent from these graphs that the t=0 measurement direct from the Calibration Rig is in many cases vastly different from the t=0 measurement from the bags. This is a surprising result, but care should be taken in drawing any firm conclusions from it. There was often a span of time of 30 minutes or more between these measurements (that is, the direct measurement was usually at least 30 minutes after the first bag measurement), and it is possible that this difference could be due to drift in the concentration being delivered by the Calibration Rig. This effect perhaps warrants further investigation to establish if it is true that for some compounds there is an immediate drop in concentration upon transfer to a sample bag.

The results below demonstrate that the compound concentration stability in sample bags varies greatly depending on the nature of the compounds involved. The two compounds whose concentrations were observed to decay most quickly were formaldehyde and hydrogen cyanide. The concentration of these two compounds dropped by ~20% within two hours. The concentration of all other compounds dropped by <10% in this time frame.[2] Given that compounds such as chloropicrin, which might be regarded as particularly ‘sticky’ did not show marked drops in measured concentration over the period of this study, and given also the low mass of hydrogen cyanide and formaldehyde and the high rate of water transfer through the walls of these bags, it is thought that the primary loss mechanism of these two compounds is diffusion through the walls of the bags.

The other clear result from these studies is that the Tedlar bags by far outperform both types of Kynar bags. Three of the compounds measured (ethene, isobutane and phosphine) showed no signs of concentration decline over the period of the study. The remaining 12 compounds all showed some signs of decline in their concentration and for all of these this decline was more severe in the Kynar bags than in Tedlar.

[1] For all compounds except xylene, the initial measurements of the three bags agreed within 10%, but normalising these all to one highlights the differences of subsequent measurements.

[2] Note that the toluene and xylene concentrations appear to have dropped by more than 10% at the time of the second measurement, but the subsequent measurements suggest that the second measurement was an outlier. Syft Standard measurements before and after the second measurement of these compounds also suggests that the transmission of benzene and xylene changed during the course of these measurements.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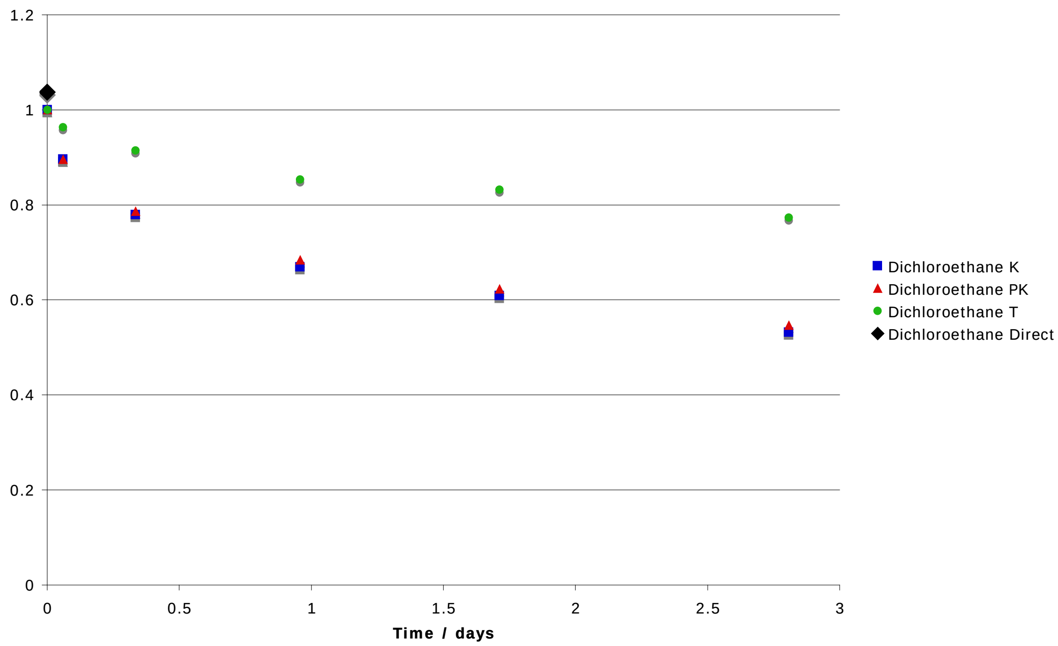
time / days
Methyl bromide K
Methyl bromide PK
Methyl bromide T
Methyl bromide Direct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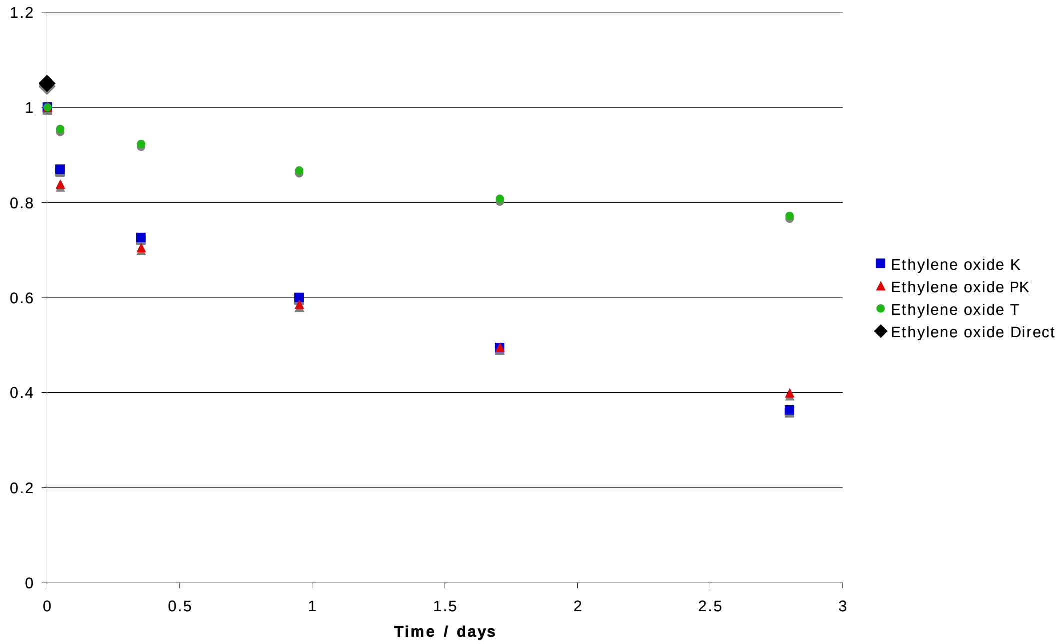
Dichloroethane PK
Dichloroethane T
Dichloroethane Direct



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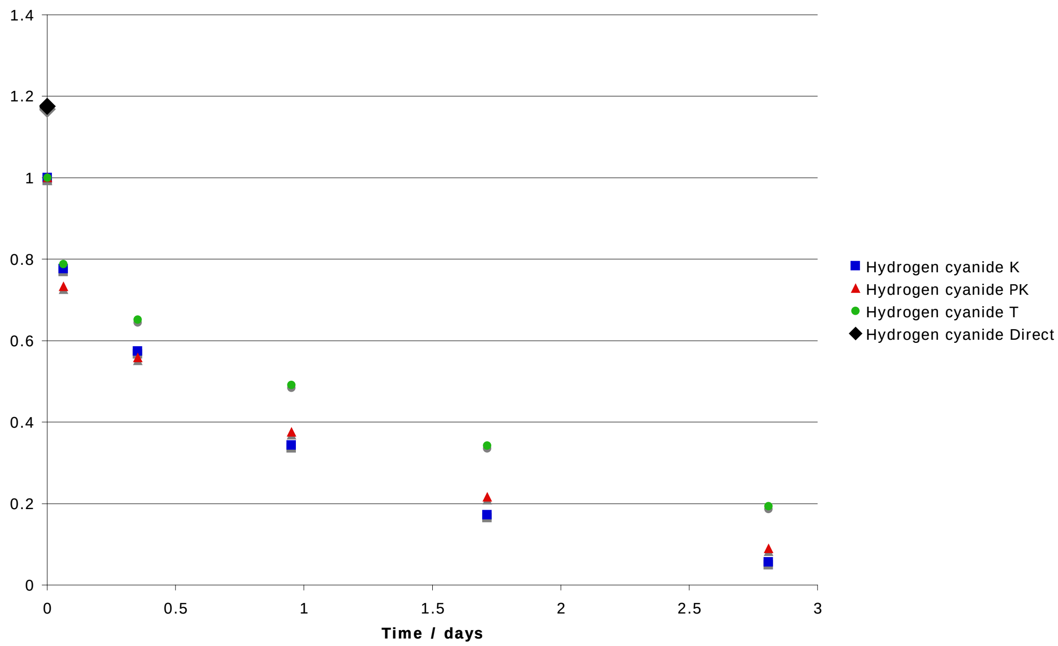
Time / days
Ethylene oxide K
Ethylene oxide PK
Ethylene oxide T
Ethylene oxide Direct



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Time / days
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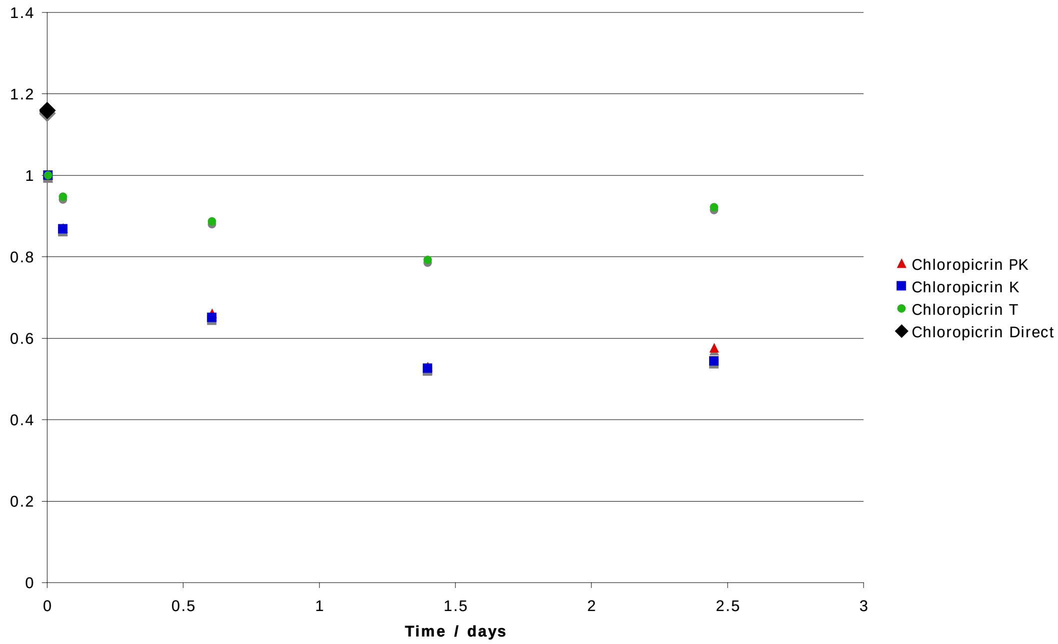
Hydrogen cyanide PK
Hydrogen cyanide T
Hydrogen cyanide Direct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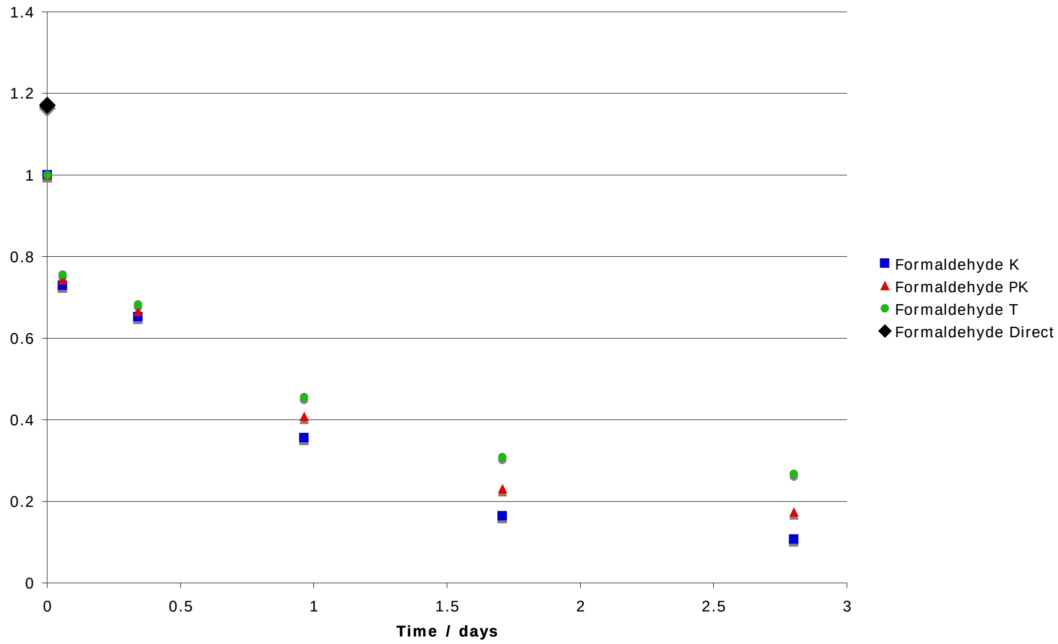
Time / days
Chloropicrin PK
Chloropicrin K
Chloropicrin T
Chloropicrin Direct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Time / days
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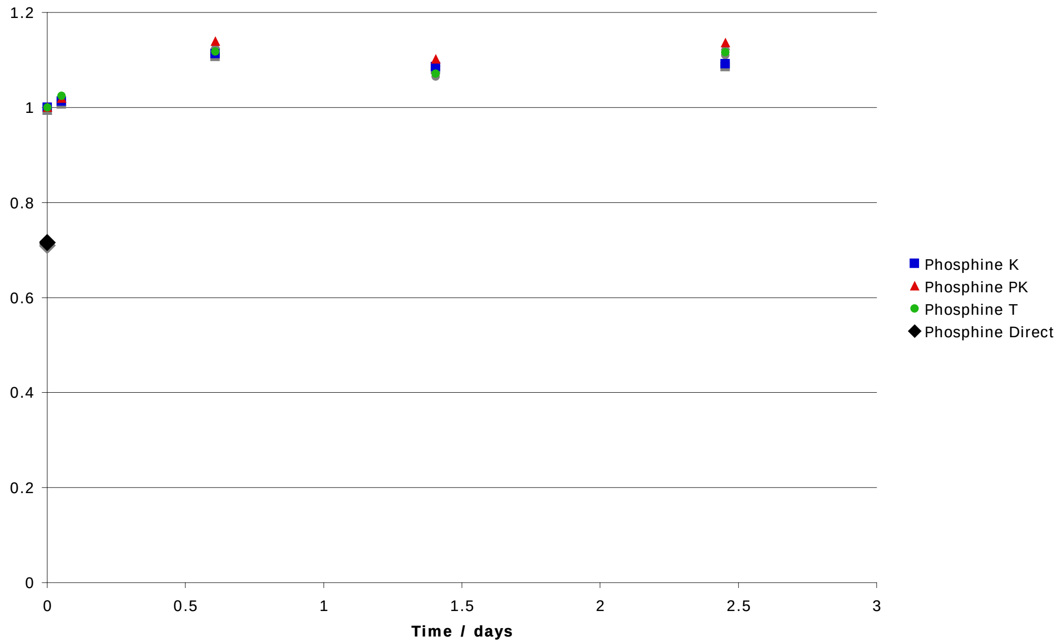
Formaldehyde PK
Formaldehyde T
Formaldehyde Direct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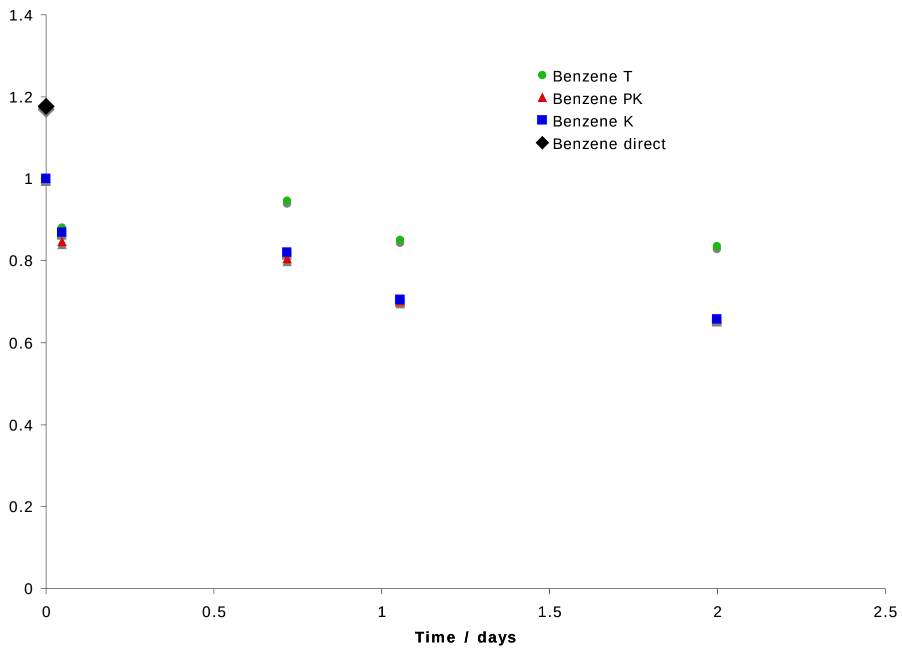
Phosphine T
Phosphine Direct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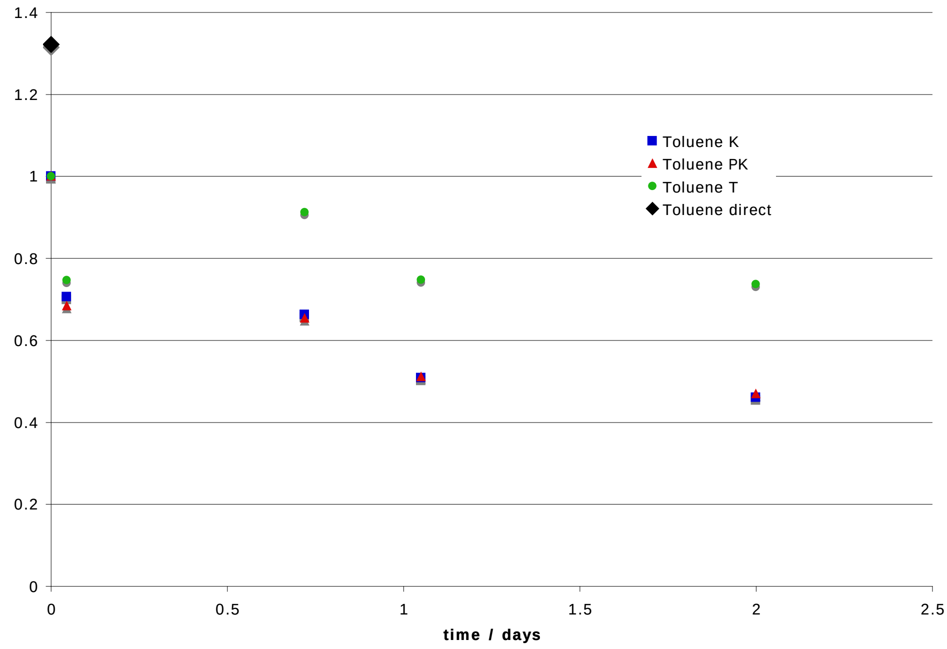
Benzene K
Benzene direct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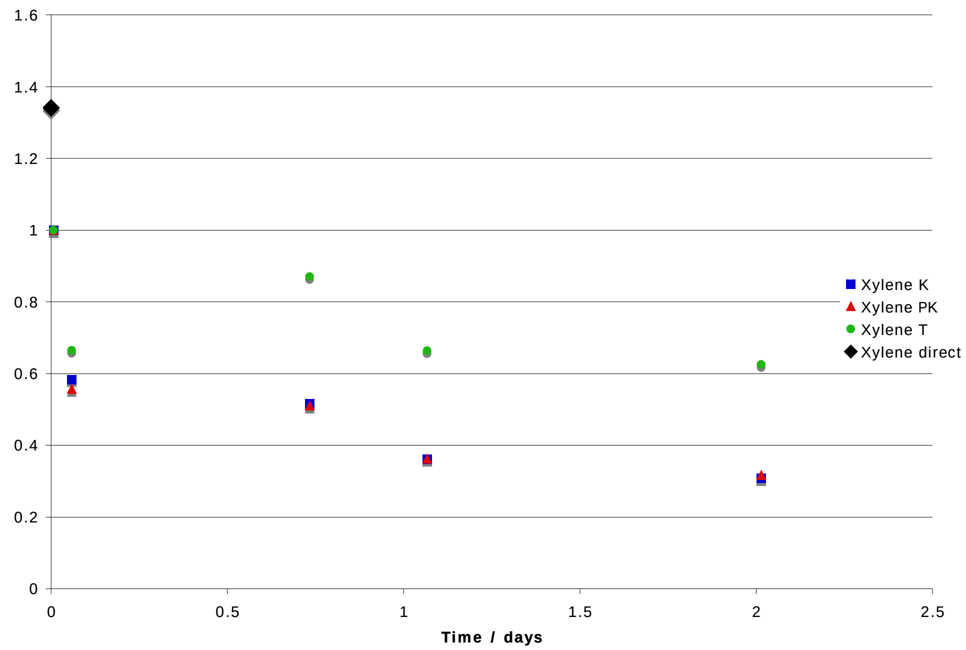
Toluene PK
Toluene T
Toluene direct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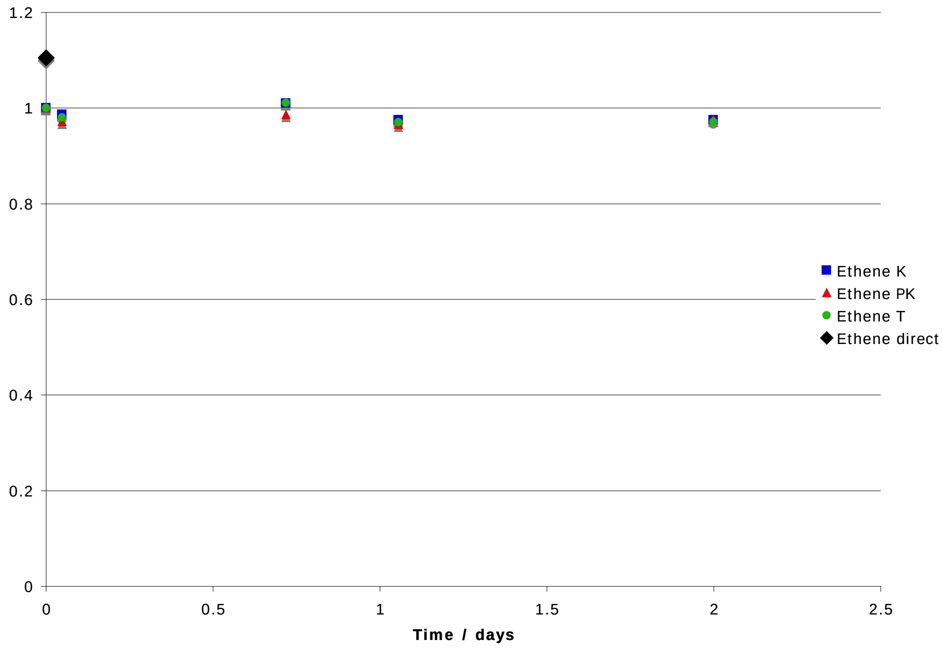
Xylene T
Xylene direct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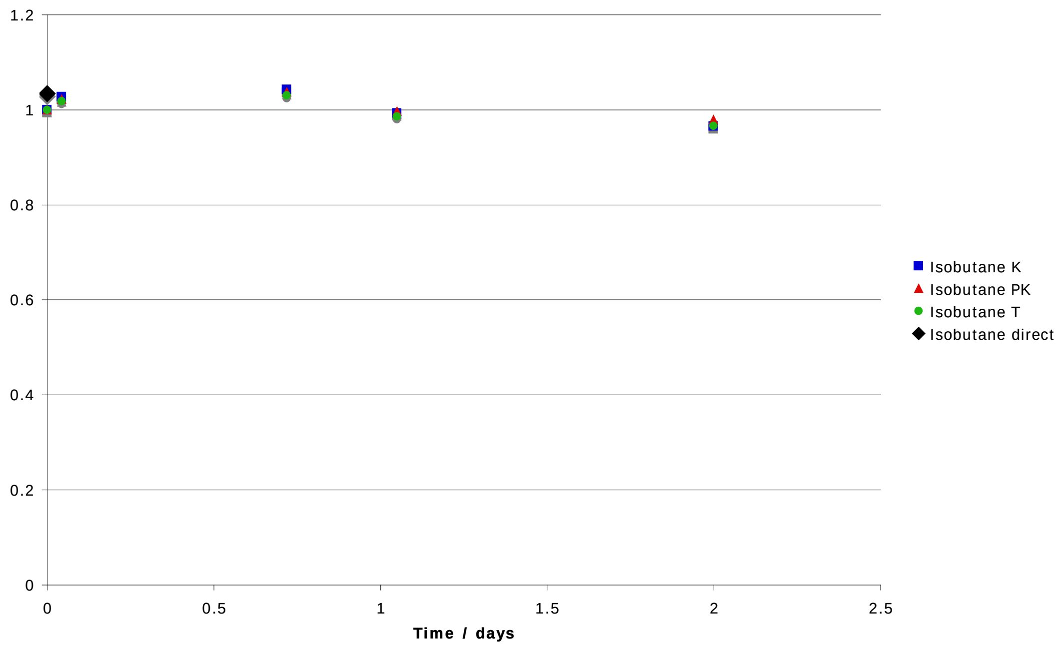
Ethene direct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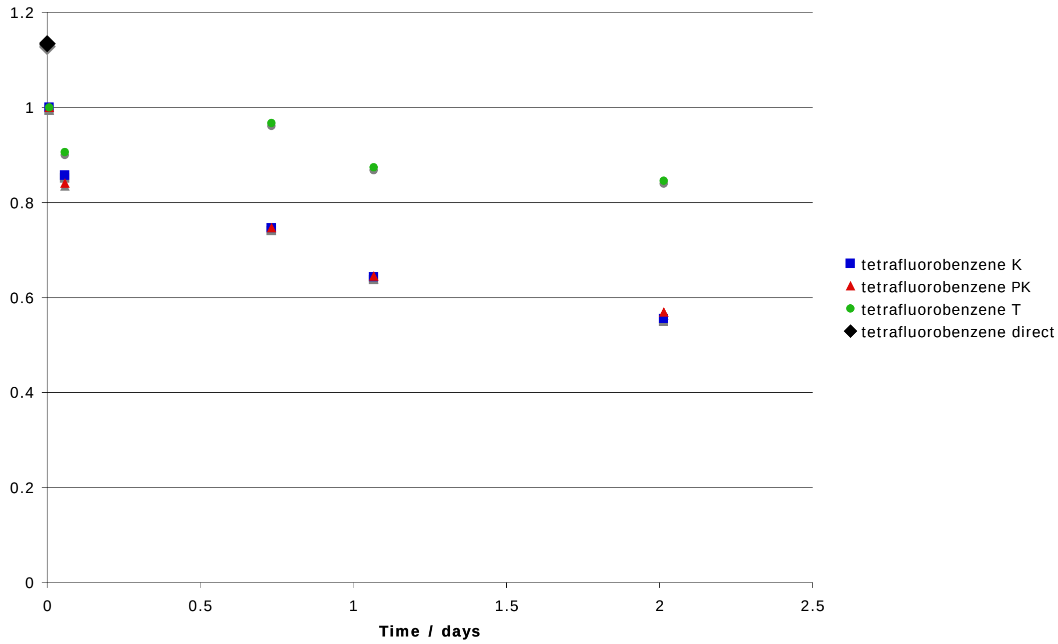
Isobutane direct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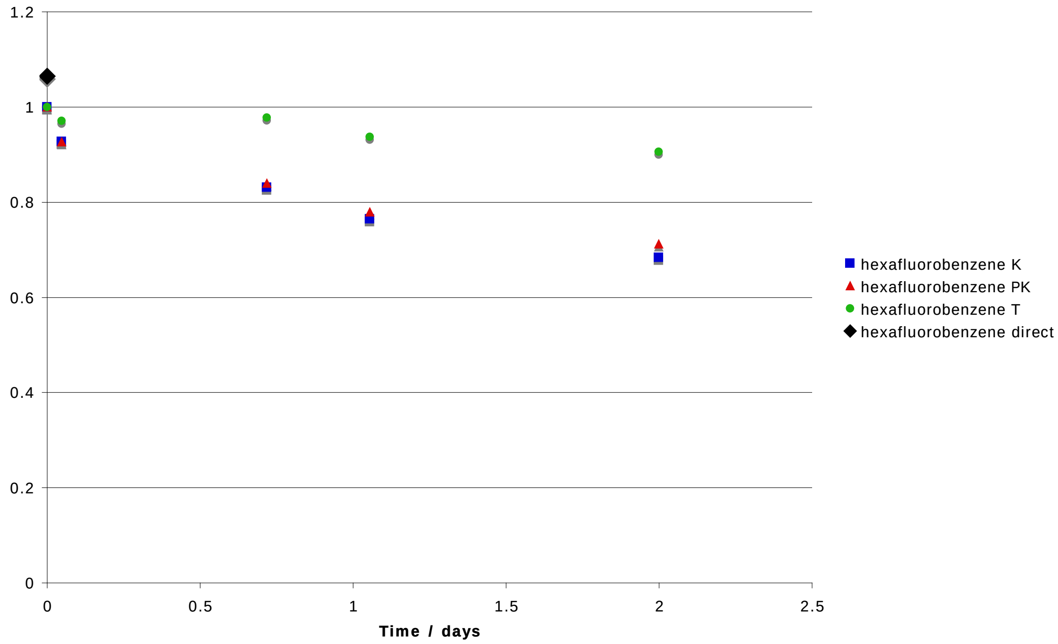
tetrafluorobenzene direct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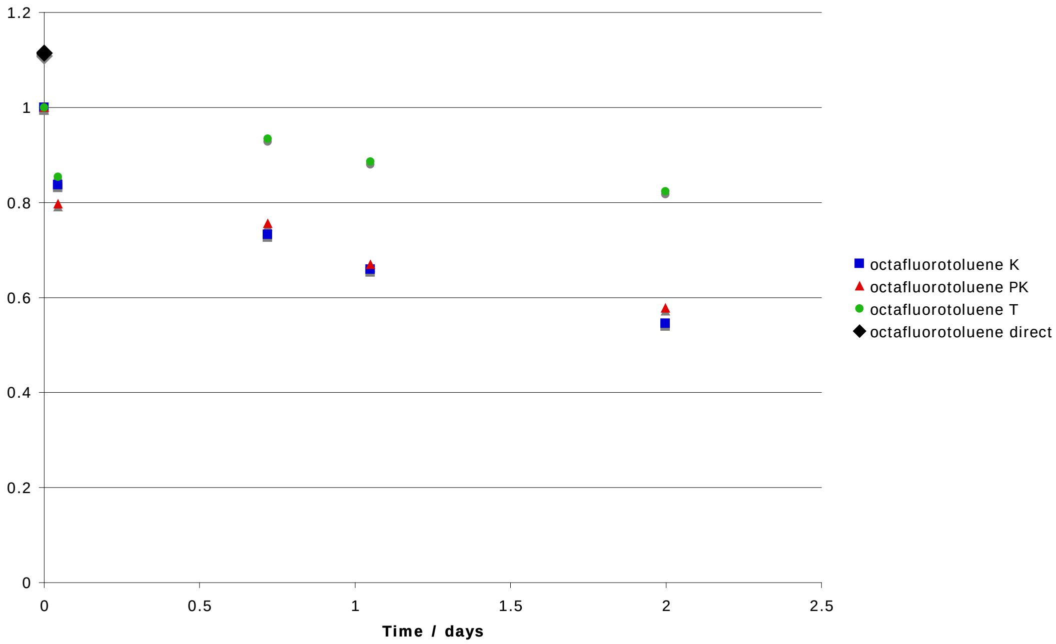

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Time / days
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octafluorotoluene PK
octafluorotoluene T
octafluorotoluene direct

Appendix 2: Health Survey

SURVEY OF OCCUPATIONAL EXPOSURES AND HEALTH STATUS	
ID Number:	
Employer:	
Workplace:	
Exposed to Fumigants:	Yes No
Number of workers employed:	
Name:	
Today's date:	
Date of Birth (DD/MM/YY):	
Sex:	Male Female

YOUR CURRENT WORK	
1. How many years have you worked in your current job?	Years
2. How many hours per week do you work in this job (on average)?	Hours per week
3. What is the main activity of the company you work for? For example, what is produced, what service is produced?	
4. Please describe your specific job in detail:	
5. In addition to your current job, do you have another job at present?	No Yes—Please specify

GENERAL HEALTH QUESTIONS	
6. Have you taken prescription drugs in the past 12 months?	No Yes I have taken prescription drugs for: Name of drug:
7. Have you ever had any of the following medical conditions?	
Cardiovascular disease (e.g. high blood pressure, heart attack, stroke, etc.)?	Yes No Don't know
Diabetes?	Yes No Don't know
8. Have you ever had any of the following problems with your nervous system?	
Muscular tremor (shaking of the muscles)?	Yes—Year observed / diagnosed No Don't know
Sensation of pins and needles?	Yes—Year observed / diagnosed No Don't know
Neurological degeneration?	Yes—Year observed / diagnosed No Don't know
Epilepsy, Parkinson's, ALS, MS?	Yes—Year observed / diagnosed No Don't know
Alzheimer's?	Yes—Year observed / diagnosed No Don't know
Other Dementia?	Yes—Year observed / diagnosed No Don't know
Coma?	Yes—Year observed / diagnosed No Don't know
Chronic Fatigue?	Yes—Year observed / diagnosed No Don't know
Other Neurological Disease? (e.g. meningitis, encephalitis)	Yes—Year observed / diagnosed No Don't know
Neurological Injury? (e.g. Carpal tunnel, sciatica)	Yes—Year observed / diagnosed No Don't know

GENERAL HEALTH QUESTIONS				
9. Have you ever had any of the following injuries?				
Head Injury?	Yes—When did this occur (year)? No Don't know			
Concussion?	Yes—When did this occur (year)? No Don't know			
10. Have you ever had or do you have any of the following emotional problems?				
Major Depression?	Yes—When did this occur (year)? No Don't know			
Severe Anxiety?	Yes—When did this occur (year)? No Don't know			
Learning Disability or Attention Deficit Disorder?	Yes—When did this occur (year)? No Don't know			
Other emotional problems?	Yes—When did this occur (year)? No Don't know			
Do you have a learning disability?	Yes No			
11. How many hours sleep do you usually get (counting naps as well) per day?	Hours			
12. How often do you get enough sleep?	Never	Rarely	Often	Always
13. How often do you wake up feeling refreshed?	Never	Rarely	Often	Always

NEUROBEHAVIOURAL SYMPTOMS
Please respond to each of the following questions by indicating how often in recent months you have experienced a particular symptom. For each question there are four possible answers: 1 – Seldom or never; 2 – Sometimes; 3 – Often; and 4 – Very often. For example: • If you <u>have not experienced</u> this symptom in recent months, circle “seldom or never" • If you have experienced this symptom <u>very often</u> in recent months, circle “very often". • If you are uncertain how often you have experienced a certain complaint, the answer that first comes into your mind is usually the best. Circle only one of the four options. When symptoms occur sometimes, often, or very often we would also like to know for how many years you have experienced these symptoms.
HOW OFTEN HAVE YOU DURING <u>RECENT MONTHS</u> EXPERIENCED ANY OF THE FOLLOWING AND FOR HOW <u>MANY YEARS</u> HAVE YOU HAD THESE SYMPTOMS?

	1 – Seldom or never	2 – Some-times	3 – Often	4 – Very often	Number of years experienced
14. Dropping things unintentionally	1	2	3	4	
15. Weakness of your arms and feet	1	2	3	4	
16. Decreased sensation in arms and legs	1	2	3	4	
17. Numbness or heaviness in your arms or legs	1	2	3	4	
18. Tingling in your arms or legs	1	2	3	4	
19. Problems with balance	1	2	3	4	
20. Changes in sense of smell or taste	1	2	3	4	
21. Decreased sensation on your face	1	2	3	4	
22. Difficulties controlling your hand movements (i.e. how often do you notice your hands are more clumsy?)	1	2	3	4	
23. Slowness in carrying out your daily activities	1	2	3	4	
24. Trembling of hands	1	2	3	4	
25. Headache	1	2	3	4	
26. Sweating for no obvious reason	1	2	3	4	
27. Nausea (i.e. do you feel sick in your stomach?)	1	2	3	4	

NEUROBEHAVIOURAL SYMPTOMS					
	1 – Seldom or never	2 – Some-times	3 – Often	4 – Very often	Number of years experienced
28. Stomach pains	1	2	3	4	
29. Dizziness	1	2	3	4	
30. Shortness of breath without physical exertion	1	2	3	4	
31. Heart fluttering (palpitations)	1	2	3	4	
32. Ringing in your ears (tinnitus)	1	2	3	4	
33. Feeling of general exhaustion	1	2	3	4	
34. Loss of sexual interest	1	2	3	4	
35. Lowered alcohol tolerance (i.e. have you noticed it takes fewer drinks than before to get drunk?)	1	2	3	4	
36. Diarrhoea	1	2	3	4	
37. Constipation	1	2	3	4	
38. Loss of appetite	1	2	3	4	
39. Feeling of a tight band around your head	1	2	3	4	
40. Difficulty getting started at work	1	2	3	4	
41. Feeling irritable	1	2	3	4	
42. Feeling depressed	1	2	3	4	
43. Feeling impatient	1	2	3	4	
44. Being upset by trivial things (i.e. do you find little things upset you?)	1	2	3	4	
45. Feeling restless	1	2	3	4	
46. Rapid changes in mood	1	2	3	4	
47. Feeling of detachment (i.e. do you feel out of touch with your surroundings?)	1	2	3	4	

NEUROBEHAVIOURAL SYMPTOMS					
	1 – Seldom or never	2 – Some-times	3 – Often	4 – Very often	Number of years experienced
48. Lack of drive (i.e. lack of energy)	1	2	3	4	
49. Lack of interest in social activities	1	2	3	4	
50. Difficulty in controlling anger	1	2	3	4	
51. Forgetfulness	1	2	3	4	
52. Having to write notes to remember things	1	2	3	4	
53. Forgetting what you were about to say or do	1	2	3	4	
54. Difficulty in concentrating	1	2	3	4	
55. Daydreaming	1	2	3	4	
56. Feeling confused when you try to concentrate	1	2	3	4	
57. Difficulty remembering names and dates	1	2	3	4	
58. Absent-mindedness	1	2	3	4	
59. Difficulty remembering what you have read or seen on TV	1	2	3	4	
60. Other people complaining about your memory	1	2	3	4	
61. Falling asleep when not in bed	1	2	3	4	
62. Unusual tiredness in the evening	1	2	3	4	
63. Sleepiness	1	2	3	4	
64. Feeling tired when you wake up	1	2	3	4	
65. Lack of energy	1	2	3	4	
66. General weariness (or tiredness)	1	2	3	4	
67. Needing more sleep than you used to	1	2	3	4	

NEUROBEHAVIOURAL SYMPTOMS					
	1 – Seldom or never	2 – Some-times	3 – Often	4 – Very often	Number of years experienced
68. Difficulty falling asleep	1	2	3	4	
69. Broken sleep	1	2	3	4	
70. Waking up too early	1	2	3	4	
71. Nightmares	1	2	3	4	
72. Snoring – that someone else has complained about	1	2	3	4	

HOW OFTEN HAVE YOU IN RECENT MONTHS, EXPERIENCED ANY OF THE FOLLOWING SYMPTOMS <u>DURING OR DIRECTLY AFTER WORK</u>?				
	1 – Seldom or never	2 – Some-times	3 – Often	4 – Very often
73. Irritation of the eyes	1	2	3	4
74. Feeling drunk without drinking alcohol	1	2	3	4
75. Dryness of the mouth or throat	1	2	3	4
76. Throat irritation	1	2	3	4
77. A runny nose	1	2	3	4
78. An unpleasant taste in your mouth	1	2	3	4

PLEASE INDICATE HOW SENSITIVE YOU USUALLY ARE TO THE FOLLOWING CONDITIONS: For example, if you feel you are very sensitive to bright lights, circle the option "strongly agree", but if you are not at all sensitive to bright lights, circle "strongly disagree".				
I am generally sensitive to:	1 – Seldom or never STRONGLY DISAGREE	2 – Some-times	3 – Often	4 – Very often STRONGLY AGREE
79. Bright lights	1	2	3	4
80. Traffic noise, loud music or other loud noises	1	2	3	4
81. Strong smells	1	2	3	4
82. Rough fabrics next to my skin	1	2	3	4
83. Heat	1	2	3	4

NEUROBEHAVIOURAL SYMPTOMS				
84. Cold	1	2	3	4
85. Tobacco smoke	1	2	3	4
86. Certain foods	1	2	3	4
PLEASE RESPOND TO THE STATEMENTS BELOW, USING THE FOLLOWING CATEGORIES (CIRCLE ONLY ONE OPTION)				
	1 – Seldom or never	2 – Some-times	3 – Often	4 – Very often
87. I am generally a nervous person	1	2	3	4
88. I think I am generally less capable then others in overcoming my difficulties	1	2	3	4
89. I worry a lot about trivial things	1	2	3	4
90. I often feel that something bad may happen at any moment	1	2	3	4
91. I often feel that even trivial problems are too much for me	1	2	3	4
92. I usually feel insecure	1	2	3	4
PLEASE ANSWER THE FOLLOWING QUESTIONS (CIRCLE ONLY ONE OPTION)				
93. How good is your health?	1 – Very good	2 – Good	3 – Poor	4 – Very poor
94. How is your health now, compared with what it was five years ago?	1 – Better	2 – About the same	3 – Worse	4 – Much worse
95. How do you feel about your life in general?	1 – Good	2 – Average	3 – Not very good	4 – Bad
96. How do you feel about your life now, compared to five years ago?	1 – Better	2 – About the same	3 – Worse	4 – Much worse

QUESTIONS ABOUT RESPIRATORY HEALTH AND ALLERGIES	
97. Have you had wheezing or whistling in your chest at any time in the past 12 months?	Yes No—If you have answered 'No' please go to question 101
98. Have you been at all breathless when the wheezing noise was present?	Yes No
99. Have you had this wheezing or whistling in the chest when you did not have a cold?	Yes No
100. How many attacks of wheezing or whistling have you had in the past 12 months?	None 1–3 times 4–2 times More than 12 times
101. Have you woken up with a feeling of tightness in your chest at any time in the past 12 months?	Yes No
102. Have you been woken by an attack of shortness of breath at any time in the past 12 months?	Yes No
103. Have you been woken by an attack of coughing at any time in the past 12 months?	Yes No
104. Have you ever had asthma?	Yes No—If you have answered 'No' please go to Question 110
105. Was the diagnosis confirmed by a doctor?	Yes No
106. How old were you when you had your first attack of asthma?	Years
107. How old were you when you had your last attack of asthma?	Years
108. Have you had an attack of asthma in the past 12 months?	Yes No
109. Are you currently taking any medicine (including inhalers, aerosols or tablets) for asthma?	Yes No
110. Do you cough almost daily for at least part of the year?	Yes No
111. Do you cough up phlegm almost daily for at least part of the year?	Yes No
If you have answered 'Yes' to either or both questions '110 and 111' please go to question 112. **If you have answered 'No' to both questions please go to question 113.**	

QUESTIONS ABOUT RESPIRATORY HEALTH AND ALLERGIES						
112. How often, during the past 12 months (or if you had this job for less than a year, how often since you started), have you had one or more of the following symptoms? (Please indicate whether symptoms lessen or disappear during weekends or holidays)						
	How often?				Lessen or disappear during weekends and holiday?	
	Daily or almost daily	1–2 times per week	1–2 times per month	Never or seldom	No	Yes
Dry cough	Daily or almost daily	1–2 times per week	1–2 times per month	Never or seldom	No	Yes
Cough with phlegm	Daily or almost daily	1–2 times per week	1–2 times per month	Never or seldom	No	Yes
Wheezing in the chest	Daily or almost daily	1–2 times per week	1–2 times per month	Never or seldom	No	Yes
Breathlessness with wheezing	Daily or almost daily	1–2 times per week	1–2 times per month	Never or seldom	No	Yes
Shortness of breath	Daily or almost daily	1–2 times per week	1–2 times per month	Never or seldom	No	Yes
Chest tightness	Daily or almost daily	1–2 times per week	1–2 times per month	Never or seldom	No	Yes
113. Have you smoked more than 100 cigarettes in total in your whole life?	Yes No					
114. Do you smoke now?	Yes No—What age did you quit smoking (years)?					
115. How many cigarettes per day do you or did you smoke?	Cigarettes per day					
116. At what age did you start smoking regularly (that is at least once a day)?	Years					

Thank you very much for your time in completing this questionnaire

NOTE: This questionnaire has been reformatted for this report to meet accessibility requirements. The questionnaire used included a number of check boxes and text boxes where worker responses could be ticked or written.

Appendix 3: Hazard Survey

INTRODUCTION

The information and opinions you provide will be strictly confidential and used only for research purposes. Your name and employer details cannot be linked to this survey.

Note: This survey will ask you questions about chemical fumes in shipping containers. The term ‘chemical fumes’ covers:

- trace amounts of gases used to eradicate pests from goods shipped to Australia (fumigants), and
- solvent vapours that might be given off from recently manufactured products, such as glues used in wood products or oils used on machine parts.

The term does not cover designated dangerous goods or chemical products.

This survey will also ask you questions about unpacking shipping containers. For the purposes of this survey **unpacking means entering a container on foot or on a vehicle for the purpose of inspecting, shifting contents, or unloading contents.**

SECTION 1: The person and their work

Q1	GENDER	Male	1
		Female	2

Q2	What is your age?	18 to 24	1
		25 to 34	2
		35 to 44	3
		45 to 54	4
		Over 55	5

Q3	How long have you been working in your current trade/occupation?	Less than 3 months	1
		3 months to 1 year	2
		1 year to 5 years	3
		5 to 10 years	4
		Over 10 years	5

Q4	How often do you unpack shipping containers?	Daily	1
		2–3 times per week	2
		Once per week	3
		Less than once per week	4

Q5	For how many years have you been unpacking shipping containers?	Less than 1 year	1
		1 year to 5 years	2
		5 years to 10 years	3
		10 years to 20 years	4
		Over 20 years	5

Q6	In your current job are you… **Please circle one response only.**	Working for an employer	1
		Working through a labour hire company	2
		Self-employed and employing others	3
		Self-employed working by yourself	4

If you are not working for an employer or a labour hire agency (Q6=3 or 4), please go to Q8

Q7	If working for an employer or labour hire agency are you employed as… **Please circle one response only.**	Permanent 1 Fixed term contract 2 Temporary or casual 3

Q8	In your job, do you usually work alone or with others?	Alone 1 With others 2

Q9	Have you completed any specific WHS training related to safely unpacking shipping containers?	Yes 1 No 2
a.	If yes, what topics were covered in your WHS training? **Please circle all that apply.**	Identifying shipping containers that may give off chemical fumes 1 Risks of exposure to chemical fumes and/or how exposures occur 2 Properties of specific chemical fumes – i.e. characteristic odours or other properties that may help identify if they are present, or responses to exposures such as skin and eye irritation, runny nose 3 Selection and use of PPE 4 Administrative controls – i.e. clearance procedures, waiting for chemical fumes to disperse before entering containers, exclusion zones during natural or mechanical ventilation periods, etc. 5 Reporting incidents 6 Other **SPECIFY** 7

SECTION 3: Knowledge about the risks of unpacking containers

Q10	Which of the following best describes your general understanding of the risks of chemical fumes in shipping containers? **Please circle one response only.**	I know a lot about chemical fumes in shipping containers 1 I know a little about chemical fumes in shipping containers 2 I don't know much about chemical fumes in shipping containers 3

Q11	Where have you learned about the risks of chemical fumes in shipping containers? **You can circle more than one response.**	Trade training 1 Newspapers or television news 2 WorkSafe/WorkCover advertising 3 Information from trade associations or unions 4 From WHS training 5 From my boss 6 From co-workers 7 Other **SPECIFY** 8

Q12	Which of these information sources was most useful to you? **Please circle only one of the responses from those you chose at Q11.**	Trade training	1
		Newspapers or television news	2
		WorkSafe/WorkCover advertising	3
		Information from trade associations or unions	4
		From WHS training	5
		From my boss	6
		From co-workers	7
		Other **SPECIFY**	8

Q13	Regardless of your answers at Q11 and Q12, have you read a code of practice or other guidance on how to manage any WHS risks when unpacking shipping containers?	Yes	1
		No	2
a.	If you answered 'Yes' to Q13, which code(s) or guidance have you read? **Please circle all that apply.**	Safe Work Australia code or guidance	1
		State or Territory WorkCover/WorkSafe code or guidance	2
		(**SPECIFY** which States and/or Territories)	
		Guidance produced by an industry association	3
		Guidance produced by trade union	4
		Other **SPECIFY**	5

SECTION 4: Perception of the risk of exposure to chemical fumes

Q14	In your current job, how likely do you think it is that you will be exposed to chemical fumes when you unpack shipping containers? **Select a ranking from 1 to 5, where 1 is 'Very unlikely' and 5 is 'Very likely'**.	Very unlikely	1
			2
			3
			4
		Very likely	5
		Don't know	6

Q15	How harmful do you think exposures to chemical fumes in shipping containers could be to your health? **Select a ranking from 1 to 5, where 1 is 'Not very harmful' and 5 is 'Extremely harmful / possibly fatal'.**	Not very harmful	1
			2
			3
			4
		Extremely harmful/possibly fatal	5
		Don't know	6

Q16	When working, do you feel you are able to protect yourself from chemical fumes in shipping containers?	Yes	1
		No	2

Q17	Now thinking of other hazards in the workplace, how would you rate the risk of harm to workers from the following activities? **For each, select a ranking from 1 to 5, where 1 is 'No risk or negligible risk' and 5 is 'Extremely high risk'.**					
	No risk or negligible				Extremely high risk	Don't know
a. Working at heights above 2 metres	1	2	3	4	5	6
b. Working with forklifts	1	2	3	4	5	6
c. Working with large machinery or plant, such as cranes or hoists	1	2	3	4	5	6
d. Lifting or moving heavy objects	1	2	3	4	5	6
e. Working in areas with moving vehicles	1	2	3	4	5	6

SECTION 5: Identifying shipping containers that may give off chemical fumes

Q18	Now thinking back to chemical fumes, how would you normally find out if the shipping container you are unpacking may give off chemical fumes?		
		I look for warning notices on the container	1
		I ask to see a clearance certificate or ask to see other information about the goods in the shipping container	2
		I ask the owner/manager of the workplace	3
		I ask my employer	4
		I ask another worker	5
		I use my own experience	6
		I would not do anything	7
		Other **SPECIFY**	8

Q19	What would you consider would most help you to identify whether a shipping container may give off chemical fumes? **Please circle one response only.**		
		Warning notices on the shipping container	1
		Reliable access to information about the contents of the shipping container, including clearance certificates	2
		Reliable information from the owner/manager of the workplace	3
		Specific WHS training on unpacking shipping containers	4
		Other **SPECIFY**	5

Q20	How well do you think you are able to identify if a shipping container may give off chemical fumes? Would you say you…?		
		Can readily identify most of them	1
		Can identify many of them	2
		Have a limited ability to identify them	3
		Are not able to identify them	4

SECTION 6: Unpacking shipping containers

Q21	How often do you unpack shipping containers that may give off chemical fumes? **Select a ranking from 1 to 5, where 1 is 'Rarely' and 5 is 'Every day'**.	Rarely	1
			2
			3
			4
		Every day	5
		Don't know	6

Q22	When you are unpacking shipping containers what safety precautions do you take?		
a.	Firstly, what do you do before you start?	Check to see if the shipping container may give off chemical fumes	1
		Ensure the shipping container is in a designated open area with good ventilation	2
		Set up barricades and place warning signs around the entrance to the shipping container	3
		Get instructions from my employer/manager	4
		Other **SPECIFY**	5
b.	What do you do before entering shipping containers?	Open the shipping container taking reasonable care to avoid exposures to any chemical fumes	1
		Extract any chemical fumes using a mechanical equipment (blower or extractor) for at least 30 minutes	2
		Extract any chemical fumes using a natural ventilation for at least 12 hours	3
		Test the air in the container using air testing equipment	4
		Get instructions from my employer/manager	5
		Other **SPECIFY**	6
c.	What types of tools or equipment do you use to unpack shipping containers?	Forklifts	1
		Pallet trolleys	2
		Trolley hoists	3
		Other lifting aids **SPECIFY**	4
		None	5

d.	How do you protect yourself from chemical fumes when unpacking shipping containers?	Wear PPE **SPECIFY**	1
		Partially unpack a tightly packed shipping container and then vent it again for a short period of time, repeating the process until unpacking is completed	2
		Continually test the air in the container using air testing equipment	3
		Ensure rescue procedures are in place	4
		Get instructions from my employer/manager	5
		Other **SPECIFY**	6

Q23	Does your employer provide you with specific safety procedures to follow when unpacking shipping containers?	Never	1
			2
			3
			4
		Always	5
		Don't know	6

Q24	When unpacking shipping containers how often do you follow your employer's safety procedures? **Select a ranking from 1 to 5, where 1 is 'Never' and 5 is 'Always'**.	Never	1
			2
			3
			4
		Always	5
		Don't know	6

If you responded with a 1-'Never', 2, or 6-'Don't know' at Q24 please go to Q27.

Q25	How important are the following factors when you take safety precautions when unpacking shipping containers? **Select a ranking from 1 to 5, where 1 is 'Not important' and 5 is 'Very important'.**					
	Not important				Very important	Don't know
a. Awareness that the shipping container may give off chemical fumes	1	2	3	4	5	6
b. Media awareness campaigns	1	2	3	4	5	6
c. Training in procedures for unpacking shipping containers	1	2	3	4	5	6
d. My supervisor/boss ensures that we follow safety procedures (good supervision)	1	2	3	4	5	6
e. My co-workers all wear protection and follow the safety rules	1	2	3	4	5	6
f. I want to protect myself from exposure to chemical fumes	1	2	3	4	5	6
g. The necessary safety equipment is provided	1	2	3	4	5	6
h. Involvement of unions on the site	1	2	3	4	5	6
i. Fear of inspection and prosecution by WHS inspectors	1	2	3	4	5	6

Q26	Which of these reasons is most important to you? **Please circle one response only.**		
		Awareness that the shipping container may give off chemical fumes	01
		Media awareness campaigns	02
		Training in procedures for unpacking shipping containers	03
		My supervisor/boss ensures that we follow safety procedures (good supervision)	04
		My co-workers all wear protection and follow the safety rules	05
		I want to protect myself from exposure to chemical fumes	06
		The necessary safety equipment is provided	07
		Involvement of unions on the site	08
		Fear of inspection and prosecution by WHS inspectors	01
		None	10

Q27	Why **DON'T** you take safety precautions when unpacking shipping containers? **ALL workers need to answer this question.** **Please circle all that apply.**	I am not aware that the shipping container may give off chemical fumes	01
		I have no training for unpacking shipping containers	02
		My supervisor/boss doesn't enforce safety procedures (poor supervision)	03
		My co-workers don't follow safety procedures	04
		I don't think there is much risk to myself from exposure to chemical fumes	05
		I am prepared to take the risk (it's a lottery anyway)	06
		I don't think the safety procedures are very effective (not worth the effort)	07
		I don't have confidence in being able to take necessary safety precautions	08
		The necessary safety equipment is not provided	09
		Wearing the protective equipment is uncomfortable or makes the task more difficult	10
		It takes too long to follow the safety procedures (too difficult, too complicated)	11
		It is too expensive to do everything by the book	12
		There is little chance of being detected by WHS Inspectors	13
		Don't know	14
		Other **SPECIFY**	15

Q28	Which of these reasons is the most significant reason for not taking safety precautions? **Please circle one response only.**	I am not aware that the shipping container may give off chemical fumes	01
		I have no training for unpacking shipping containers	02
		My supervisor/boss doesn't enforce safety procedures (poor supervision)	03
		My co-workers don't follow safety procedures	04
		I don't think there is much risk to myself from exposure to chemical fumes	05
		I am prepared to take the risk (it's a lottery anyway)	06
		I don't think the safety procedures are very effective (not worth the effort)	07
		I don't have confidence in being able to take necessary safety precautions	08
		The necessary safety equipment is not provided	09
		Wearing the protective equipment is uncomfortable or makes the task more difficult	10
		It takes too long to follow the safety procedures (too difficult, too complicated)	11
		It is too expensive to do everything by the book	12
		There is little chance of being detected by WHS Inspectors	13
		Don't know	14
		Other **SPECIFY**	15

THANK YOU FOR YOUR PARTICIPATION

Appendix 4. SIFT-MS results for RAGS samples

Container ID	Contents	1,2-dibromoethane	1,2-dichloroethane	C2-alkylbenzenes	ammonia	benzene	chloropicrin	ethylene oxide	formaldehyde	hydrogen cyanide	hydrogen phosphide	methyl bromide	styrene	toluene
10*	1	-	-	0.016	-	-	-	-	-	-	-	0.069	0.005	0.021
11*	4	-	-	0.016	-	-	-	-	0.209	-	-	0.04	-	0.071
12	1	-	-	0.02	-	-	-	-	-	-	-	-	0.01	0.025
13	2	-	-	0.135	-	-	-	-	-	-	-	0.061	0.015	0.022
14*	1	-	-	0.014	-	-	-	-	-	-	-	0.041	0.007	0.033
14	1	-	-	0.01	-	-	-	-	-	-	-	-	-	0.02
15	2	-	-	0.037	-	0.029	-	-	-	-	-	0.336	-	1.804
16*	1	-	-	-	-	-	-	-	-	-	-	-	-	0.015
16	1	-	-	0.044	-	-	-	-	-	-	-	0.049	0.011	0.039
17	1	-	-	0.011	-	-	-	-	-	-	-	-	-	0.016
18	1	-	-	-	-	-	-	-	-	-	-	-	-	-
20	2	-	0.163	0.711	-	-	0.118	-	-	-	0.004	0.101	0.067	0.384
21	4	-	0.432	0.646	-	0.04	0.259	-	0.191	0.029	-	0.274	0.074	0.97
22	1	-	-	0.131	-	-	-	-	-	-	-	0.044	0.014	0.024
23	2	-	-	0.009	-	-	-	-	-	-	-	-	-	0.016
24	1	0.094	0.052	0.034	-	-	-	-	0.897	-	0.021	0.654	0.014	0.056
25	3	0.138	0.048	0.101	-	-	0.045	-	-	-	0.003	3.749	0.018	0.195
25*	3	-	-	0.013	-	-	-	-	-	-	-	0.149	-	0.035
26	1	-	1.791	0.459	-	-	-	-	0.265	-	0.003	0.133	0.008	1.768

Container ID	Contents	1,2-dibromoethane	1,2-dichloroethane	C2-alkylbenzenes	ammonia	benzene	chloropicrin	ethylene oxide	formaldehyde	hydrogen cyanide	hydrogen phosphide	methyl bromide	styrene	toluene
27	2	0.9	9.6	2.982	0.022	0.053	0.1	-	2.004	-	0.031	0.596	0.085	10.459
28	1	-	-	0.035	-	-	-	-	-	-	-	0.039	-	0.146
28*	1	-	-	-	-	-	-	-	-	-	-	-	-	0.065
29	1	-	-	-	-	-	-	-	-	-	-	0.037	-	0.035
30	1	-	-	0.016	-	-	-	-	-	-	-	-	0.006	0.044
31	2	-	-	0.02	-	-	-	-	-	-	-	0.069	-	0.028
32	1	-	-	0.011	-	-	-	-	-	-	-	-	-	0.013
32*	1	-	-	-	-	-	-	-	-	-	-	0.04	-	0.033
32	1	-	0.021	0.053	-	-	-	-	-	-	-	0.184	0.01	0.05
33	4	-	-	0.036	-	-	-	-	0.438	-	0.008	0.498	0.011	0.029
34	3	0.341	0.066	3.346	0.019	0.018	1.625	-	0.405	-	0.006	4.428	0.021	0.261
35	4	-	-	0.078	-	-	-	-	-	-	-	0.105	0.006	0.016
36	3	-	-	0.053	-	-	-	-	-	-	-	0.1	0.005	0.011
41	4	-	-	0.013	-	0.022	-	-	-	-	-	-	-	0.072
41*	4	-	0.053	0.05	-	-	-	-	-	-	-	0.056	0.011	0.018
42	2	-	0.027	0.012	-	0.029	-	-	0.134	-	-	-	-	0.085
43	1	0.064	0.057	4.859	-	0.051	0.239	-	-	-	-	0.222	0.029	0.717
43*	1	-	0.038	0.336	-	-	-	-	0.822	-	0.006	0.079	0.033	0.023
47	1	-	-	0.04	-	-	-	-	-	-	0.008	0.053	0.022	0.178
48	3	-	-	-	-	-	-	-	-	-	0.006	1.7	-	0.014
49	3	-	-	-	-	-	-	-	-	-	-	1.245	-	0.047

Container ID	Contents	1,2-dibromoethane	1,2-dichloroethane	C2-alkylbenzenes	ammonia	benzene	chloropicrin	ethylene oxide	formaldehyde	hydrogen cyanide	hydrogen phosphide	methyl bromide	styrene	toluene
50	2	-	-	-	-	-	-	-	-	-	-	-	-	0.027
51	2	-	-	-	-	-	-	-	-	-	-	-	-	0.011
52	2	-	-	-	-	-	-	-	-	-	-	0.067	-	0.045
53	1	-	-	0.033	-	-	-	-	-	-	0.007	0.047	-	0.016
54	1	-	-	0.014	-	-	-	-	-	-	-	-	-	0.042
55	1	-	-	-	-	-	-	-	-	-	-	-	-	-
56	3	-	-	0.02	-	-	-	-	-	-	-	1.57	0.008	0.572
57	1	-	-	-	-	-	-	-	-	-	-	0.393	-	0.167
58	1	-	-	0.01	-	-	-	-	-	-	-	0.347	-	0.037
59	1	-	-	-	-	-	-	-	-	-	-	-	-	0.022
61	1	-	-	-	-	-	-	-	-	-	-	-	-	0.011
61*	1	-	-	0.048	-	-	-	-	-	-	-	0.192	-	0.045
62	4	-	-	0.123	-	-	-	-	-	-	-	0.467	-	0.012
63	4	-	0.018	0.28	-	-	-	-	0.285	-	0.019	0.067	0.022	0.508
64	4	-	-	-	-	-	-	-	-	-	-	0.048	-	0.028
64	4	-	-	0.05	-	-	-	-	-	-	0.004	0.433	-	0.053
65	4	-	-	0.02	-	-	-	-	-	-	0.008	0.667	-	0.045
65	4	-	-	-	-	-	-	-	-	-	-	-	-	0.014
66	4	-	-	0.827	-	-	0.06	-	0.69	-	0.02	0.137	0.103	5.887
68	2	-	-	-	-	-	-	-	-	-	-	-	-	0.02
68	2	-	-	0.03	-	-	-	-	-	-	-	0.107	-	-

Container ID	Contents	1,2-dibromoethane	1,2-dichloroethane	C2-alkylbenzenes	ammonia	benzene	chloropicrin	ethylene oxide	formaldehyde	hydrogen cyanide	hydrogen phosphide	methyl bromide	styrene	toluene
69	2	-	0.03	0.113	-	-	-	-	-	-	-	-	0.015	2.717
69	2	-	-	-	-	-	-	-	-	-	-	-	-	0.05
70*	2	-	-	0.018	-	-	-	-	-	-	-	-	0.005	0.027
70	2	-	0.022	0.01	-	-	-	-	-	-	-	-	-	0.048
71	2	-	-	-	-	-	-	-	-	-	-	-	-	0.006
74	1	-	-	-	-	-	-	-	0.225	-	-	-	0.008	0.013
74	1	-	-	-	-	-	-	-	0.14	-	-	-	-	-
74	1	-	-	-	-	-	-	-	-	-	-	0.05	0.04	0.067
75	4	-	-	-	-	-	-	-	-	-	-	-	-	-
75	4	-	-	-	0.015	-	-	-	-	-	-	-	-	-
75	4	-	-	-	-	-	-	-	-	-	-	-	-	-
75	4	-	-	-	-	-	-	-	-	-	-	-	-	-
76	1	-	-	-	-	-	-	-	0.13	-	0.004	0.05	-	-
76	1	-	-	-	-	-	-	-	-	-	-	-	-	-
76	1	-	-	-	-	-	-	-	-	-	-	-	-	-
76	1	-	-	-	-	-	-	-	0.15	-	-	-	-	-
77	4	-	-	-	-	-	-	-	-	-	-	-	-	-
77	4	-	-	-	-	-	-	-	-	-	-	-	-	-
78	2	-	-	0.017	-	-	-	-	0.175	-	-	-	-	0.36
78	2	-	-	0.012	-	-	-	-	0.155	-	-	-	-	0.355
79	4	-	-	-	0.02	-	-	-	-	-	-	-	-	0.12

Container ID	Contents	1,2-dibromoethane	1,2-dichloroethane	C2-alkylbenzenes	ammonia	benzene	chloropicrin	ethylene oxide	formaldehyde	hydrogen cyanide	hydrogen phosphide	methyl bromide	styrene	toluene
80	1	-	-	0.008	-	-	-	-	-	-	-	0.04	-	0.08
81	4	-	-	0.008	-	-	-	-	-	-	0.004	-	-	0.093
82	4	-	-	-	-	-	-	-	-	-	-	-	-	0.112
83	4	-	-	0.028	-	-	-	-	-	-	-	-	0.01	0.045
83	4	-	-	0.027	-	-	-	-	-	-	-	-	0.012	0.057
84	2	-	-	0.008	-	-	-	-	-	-	-	0.037	-	0.107
84	2	-	-	-	-	-	-	-	-	-	-	-	-	0.037
84	2	-	-	0.022	-	-	-	-	-	-	-	-	0.007	0.037
85	2	-	-	-	-	-	-	-	-	-	-	-	-	0.033
85	2	-	-	-	-	-	-	-	-	0.015	-	0.035	-	0.085
85	2	-	-	-	0.022	-	-	-	-	0.025	-	0.047	-	0.032
85	2	-	-	0.012	0.041	-	-	-	-	0.03	-	-	-	0.027
86	4	-	-	-	-	-	-	-	-	-	-	-	-	0.02
86	4	-	-	0.01	0.018	-	-	-	-	-	-	-	-	0.022
86	4	-	-	0.01	-	-	-	-	-	-	-	0.043	-	0.028
86	4	-	-	-	0.017	-	-	-	-	-	-	0.045	-	0.033
87	4	-	-	0.038	-	-	-	-	-	-	-	-	-	0.01
87	4	-	-	0.008	-	-	-	-	-	-	-	-	-	0.03
87	4	-	-	0.012	-	-	-	-	-	-	0.003	-	-	0.03
87	4	-	-	0.012	-	-	-	-	-	-	-	0.033	-	0.032
88	4	-	-	0.55	-	0.045	-	-	-	-	-	0.05	-	0.038

Container ID	Contents	1,2-dibromoethane	1,2-dichloroethane	C2-alkylbenzenes	ammonia	benzene	chloropicrin	ethylene oxide	formaldehyde	hydrogen cyanide	hydrogen phosphide	methyl bromide	styrene	toluene
88	4	-	-	0.427	-	0.035	-	-	-	-	-	0.065	-	0.043
88	4	-	-	-	-	-	-	-	-	0.02	-	-	-	0.01
88	4	-	-	0.907	-	0.067	-	-	-	-	0.003	0.045	-	0.06
89	1	-	0.045	0.015	-	-	-	-	-	-	0.004	0.055	-	0.057
89	1	-	0.14	0.018	-	-	-	-	-	-	-	-	-	0.09
89	1	-	-	-	-	-	-	0.05	-	-	0.003	-	-	0.013
89	1	-	-	-	-	-	-	-	-	-	-	-	-	-
90	4	-	-	-	-	-	-	-	-	-	-	-	-	0.038
90	4	-	-	-	0.016	-	-	-	-	-	-	-	-	0.04
91	4	-	-	-	0.017	-	-	-	-	-	-	-	-	0.02
91	4	-	-	-	-	-	-	-	-	-	-	-	-	0.088
91	4	-	-	0.01	-	-	-	-	-	-	-	0.037	-	0.077
92	2	-	0.018	0.016	0.048	-	-	-	2.324	-	0.225	0.062	-	0.028
92	2	-	0.018	0.01	0.019	-	-	-	0.799	-	0.083	0.063	-	0.032
93	2	-	-	-	-	-	-	-	-	-	-	-	-	0.015
93	2	-	-	0.015	-	-	-	-	-	-	0.006	-	-	0.023
94	4	-	-	-	-	-	-	-	-	-	0.006	0.04	-	-
94	4	-	-	-	0.147	-	-	-	-	-	-	-	-	-
94	4	-	-	-	0.084	-	-	-	-	-	0.011	-	-	-
95	2	-	-	0.009	-	-	-	-	0.126	-	-	-	-	0.16
95	2	-	-	1.007	0.017	-	0.068	-	-	-	0.004	0.287	-	0.084

Container ID	Contents	1,2-dibromoethane	1,2-dichloroethane	C2-alkylbenzenes	ammonia	benzene	chloropicrin	ethylene oxide	formaldehyde	hydrogen cyanide	hydrogen phosphide	methyl bromide	styrene	toluene
95	2	-	-	-	-	-	-	-	-	-	-	-	-	0.025
96	1	-	-	-	-	-	-	-	-	-	-	0.044	-	0.025
96	1	-	-	0.257	-	-	-	-	-	-	-	0.076	-	0.021
96	1	-	-	0.017	0.083	-	-	-	-	-	0.005	-	-	0.009
96	1	-	-	-	-	-	-	-	-	-	-	-	-	0.008
97	1	-	-	-	-	-	-	-	-	-	-	-	-	0.008
97	1	-	-	-	-	-	-	-	-	-	-	-	0.005	0.009

* Taken when the container door was opened

Notes:

Contents: 1=Metal/Glass including auto parts, tools, agricultural parts; 2=Plastics/textiles including safety clothing, storage containers, cabinets, electrical equipment; 3=Furniture including timber outdoor furniture, hydration blocks, metal furniture and misc. furniture; and 4= Miscellaneous/mixed loads including household goods, clothes, food in sealed tins, personal belongings

'-' indicates that levels were below the reporting threshold

Appendix 5. SIFT-MS results for shift samples

Container ID	Contents	1,2-dibromoethane	1,2-dichloroethane	C2-alkylbenzenes	ammonia	benzene	chloropicrin	ethylene oxide	formaldehyde	hydrogen cyanide	hydrogen phosphide	methyl bromide	styrene	toluene
1,2,3	1	-	-	0.047	-	-	-	-	-	-	-	-	-	0.049
4,5,6	1	-	-	0.009	-	-	-	-	-	-	-	-	-	0.161
7,8	4	-	-	-	-	-	-	-	-	-	-	-	-	0.054
9	4	-	0.528	-	-	-	-	-	-	-	-	-	-	0.256
19	4	-	-	0.011	-	-	-	-	-	-	-	-	-	0.12
37,38	4	-	-	0.012	-	0.084	-	-	-	-	-	-	-	1.364
39,40	4	-	-	-	-	-	-	-	-	-	-	-	-	0.145
44	1	-	-	-	-	-	-	-	-	-	-	-	-	0.07
45	1	-	-	-	-	-	-	-	-	-	-	-	-	-
46	1	-	-	0.017	-	-	-	-	-	-	-	-	-	0.075
60	2	-	-	-	-	-	-	-	0.725	-	-	0.117	-	0.039
72,72	4	-	-	0.083	-	-	-	-	-	-	-	-	-	0.067

Notes:

Contents: 1=Metal/Glass including auto parts, tools, agricultural parts; 2=Plastics/textiles including safety clothing, storage containers, cabinets, electrical equipment; 3=Furniture including timber outdoor furniture, hydration blocks, metal furniture and misc. furniture; and 4= Miscellaneous/mixed loads including household goods, clothes, food in sealed tins, personal belongings

'-' indicates that levels were below the reporting threshold