Department of Justice and Attorney-General
Workplace Health and Safety Queensland

Compliance program report – expandable polystyrene bead manufacturing 2013

August 2013

Introduction

Expandable polystyrene (EPS) beads are imported into Queensland to produce a range of polystyrene-based products. These beads are small spheres (less than 2 mm in diameter) typically imported in bulk bags as a raw material that undergoes processing to expand the beads and form them into various products. Manufacturing facilities that process EPS beads must manage the associated hazards to ensure a safe workplace. The primary hazard associated with EPS beads is fire due to their combustibility and evolution of flammable vapours associated with the blowing agent within the beads.

A state-wide inspection program was developed and implemented during the first half of 2013 for the purposes of monitoring safety at EPS bead manufacturing facilities and assessing compliance with the Work Health and Safety Regulation 2011 (WHS Regulation). The primary purpose of the program was to focus on the workplaces management of flammability hazards.

Workplace Health and Safety Queensland (WHSQ) inspected 11 workplaces that were identified as EPS bead processers where the EPS beads are expanded with steam. Sites that did not expand the beads and only cut or shape expanded polystyrene blocks were not included in this audit program.

Background

The EPS product manufacturing process is typically a three step process.

1. Pre expansion: Polystyrene beads, the size of a grain of sand are expanded to around 50 times their original size on contact with steam. The expansion process occurs due to the inclusion of a blowing agent (typically pentane) within the bead boiling-off, and thus causing the expansion. The pentane and steam are normally exhausted from the process.
2. Conditioning: The expanded beads are then stored in hoppers for a period to mature before the moulding process. Due to passive off-gassing, some pentane gas may be present in and around the storage hoppers.
3. Moulding: The pre expanded polystyrene is then placed within a mould where more steam is introduced. The pre-foamed beads expand further, completely filling the mould cavity and fuse together. The expanded beads are moulded either into blocks or customised shaped products such as food boxes, waffle pods, packaging materials, stubby holders etc.

The polystyrene blocks are normally stored for a period to ‘dry’, reducing the water content within the block. The process can be accelerated by placing the blocks in curing ovens normally set at 70°C.

Block polystyrene is then usually cut to size using a hot wire cutting table and more complex shapes cut using a computer controlled hot wire cutting machine.

Hazards

There are two principal components of EPS: solid styrenic polymer (polystyrene beads) and a blowing agent, typically pentane. Pentane content may be present in concentrations ranging from 3-8 per cent in the beads or lower for low grades of EPS which are also available. Pentane vapour is colourless, has a relative vapour density approximately 2.5 times that of air and a flammable range of 1.4 to 8.3 per cent pentane vapour-in-air. Because pentane vapour is heavier than air, it may accumulate in depressions, trenches, sumps, stairwells, enclosed areas (containers, trailers) or confined spaces (e.g. bulk storage bins and silos) that are not continuously ventilated.

This hazard is recognised in transport as the Australian Dangerous Goods Code (ADG Code) includes a UN Number entry, UN2211, as a Class 9 dangerous goods for “*polymeric beads, expandable, evolving flammable vapour*”.

Hence, the main safety hazard with transporting, storing, handling and processing EPS is the flammability hazard. Pentane (as the typical blowing agent) evaporates from the beads during storage and is increasingly driven off during the heating process for expanding the polystyrene beads. This creates a potential fire hazard if the vapours are allowed to accumulate in the

presence of potential ignition sources. Potential ignition sources include electrical equipment, static electricity discharges, and hot work such as grinding and welding.

While EPS beads are considered to be non-toxic, the presence of pentane, residual styrene monomer, any additives, thermal decomposition products (e.g. hot-wire cutting) and associated dusts may present health hazards which also need to be considered for a particular product and process. Information on this can be sought from the products safety data sheet (SDS) or directly from the EPS bead manufacturer.

Issue identification

Under the *Work Health and Safety Act 2011* (WHS Act) and the WHS Regulation, a person conducting the business or undertaking (PCBU) has an obligation to manage flammable vapours and to ensure that ignition sources are not introduced in areas where flammable gas/vapour concentrations may exist.

Following an assessment of a particular EPS bead processing facility, it was found that the flammability hazards of the process and associated controls were not well understood at that workplace. Additionally it was found that there is relatively little readily available guidance material available on safe storage, handling and processing of the polystyrene beads other than that supplied in the SDS by the manufacturer. An Australian Standard which covers polystyrene only considers the physical characteristics of finished polystyrene products. There is no reference to the storage of EPS beads or the manufacturing process. The Health and Safety Executive (HSE) in the United Kingdom has published a guideline which can be applied to manufacturing operations in Queensland and is publicly available on the internet.

As a result, WHSQ initiated a project to further assess the safe management of EPS bead processing in Queensland.

What was the purpose of this inspection program?
The purpose of this inspection program was to follow up on the issue described above at other related workplaces in Queensland. This included inspecting the safety systems associated with the handling and storage of expandable polystyrene (EPS) beads, focusing on the safe management of flammable vapours and fire prevention.

Other aims for the program included:

- ensuring the PCBU and workers are aware of the flammable gas hazards in the storage and processing of EPS beads
- raising awareness of regulatory requirements under the WHS Act
- assessing the management of hazardous chemical risks by the workplace
- improving engagement and collaboration with the industry.

What did the inspection program include?
The inspection program involved 11 workplaces state-wide which expand the EPS bead and manufacture polystyrene block or moulded products. The sites were all previously Large Dangerous Goods Locations (LDGL) under the repealed *Dangerous Goods Safety Management Act 2001* due to the sites storing more than 10 000 kg of EPS bead (based on the Class 9 dangerous goods classification) which required notification as a LDGL.

However, under the WHS Act, a number of Class 9 dangerous goods such as EPS beads are no longer captured under the definition of 'hazardous chemical[1]' and therefore will not trigger the notification requirement for a manifest quantity workplace.

These workplaces may still need to notify due to the presence of large quantities of other materials that are hazardous chemicals. For example, two sites were required to notify due to the large quantity of LPG and/or flammable liquid adhesives stored and handled on site.

[1] A new system of chemical classification and hazard communication on labels and safety data sheets (SDS), based on the *Globally Harmonised System of Classification and Labelling of Chemicals* (GHS) has come into effect under the WHS Act. Hazardous Chemicals are defined under the WHS Act as applying to specific GHS hazard classes.

Additionally, the hazardous chemicals requirements are applicable to those hazardous chemicals generated in a process such as pentane.

The inspection process

Prior to the site inspection program, WHSQ provided the manufacturer with a polystyrene audit check sheet. The workplace inspections were conducted by an inspector from the local WHSQ office and an inspector from the Hazardous Industries and Chemicals Branch.

The audit consisted of a meeting with the manufacturer in which the audit check sheet findings were discussed and evidence of application was sighted. This was followed by a site inspection looking at the various controls in place in the polystyrene manufacturing process, general storage and handling of hazardous chemicals and other workplace health and safety issues such as managing hazards from hot surfaces, working from heights, manual handling and electrical safety. The inspection concluded by discussing situations of non-compliance and negotiating timeframes to achieve compliance where required.

Enforcement activities were undertaken in accordance with the principles of the National Compliance and Enforcement Policy.

What did the inspection program target?
The program focussed primarily on managing hazardous chemicals provisions in Chapter 3 and 7.1 of the WHS Regulation. The areas covered were regulatory compliance, operational safety and emergency preparedness within the context of the Regulation. Relevant sections of the Regulation include:

- General risk management (r32-38)
- maintaining a hazardous chemicals register (r346)
- hazardous chemical placards (r350)
- safety signs (r353)
- controlling ignition sources on site (r355)
- containing and managing spills on site (r357)
- provision and maintenance of fire fighting equipment (r359)
- controlling risk from the storage and handling system (r363)
- provision of information, supervision, education & training (r363 and 39)
- emergency plans (r43)
- housekeeping (r40)
- hot pipes (r209)
- guarding (r208)
- manual handling (r60)
- working from heights (r78)
- general electrical safety (r40).

What were the results of the inspection program?
Of the 11 workplaces inspected as part of this program the level of general compliance was high. Eight improvement notices were issued under the WHS Act , with the breakdown of notices issued for specific issues shown in Table 1.

Table 1. Notices issued under the WHS Act and Regulation

Issue	Regulation	Notices	Comment
Venting within building	355	3	Pentane / Steam not exhausted outside
Permit system	355	1	No systems in place
Earthing	355	2	Not seen or PCBU unable to confirm
Electrical equipment	355	1	Located in a hazardous zone
Placard	350	1	Poor condition

The overall compliance with the requirements of the WHS legislation was generally good. Most workplaces had established safety management systems with documentation available on work permits, safe work procedures, emergency preparedness, staff training records and equipment inspection records. Two workplaces inspected had very limited documentation other than some maintenance records.

All the workplaces were aware of the flammability hazard of pentane and had various controls in place to mitigate the hazard. Two workplaces have actually conducted a hazardous area classification for their sites which is commendable. Three workplaces had conducted pentane measurements around the factory to verify the absence or presence of pentane during the production process.

There is no specific requirement to conduct a hazard area classification, however the PCBU has a duty to identify hazards and develop appropriate controls using the hierarchy of controls. By conducting vapour monitoring the PCBU can help demonstrate that pentane hazard has been eliminated on site. At three workplaces, the possible accumulation of pentane had not been controlled in the polystyrene pre-foamer area due to the lack of venting to the outside of the building. All the other workplaces inspected were observed to have had this control measure in place. The existing guidance material from the UK Heath and Safety Executive and SDS guidance suggests that exhaust gasses be exhausted to a safe location. This deficiency resulted in improvement notices being issued.

All workplaces were observed to have earthing straps attached to manufacturing equipment, transfer ducting and storage hoppers. However, in most cases no checks were being conducted to determine if this control measure was working. Only two sites actually tested the continuity of the system, but were unable to provide documentary evidence that this is being done at regular intervals.

Discussion

Process risk controls

Of the 11 polystyrene manufacturers six were block moulders, three produced packages as well as block and two solely package or waffle pod products. Six of the block manufacturers had drying ovens on site and all the block manufacturers had the additional manually or computer controlled hot wire cutting tables.

Receiving and storage of EPS beads

Most of the facilities audited received the raw EPS beads on open trucks from the supplier. The manufacturers that imported EPS bead directly were aware of the hazard of vapour build up within transport containers and had documented work procedures in place to safely manage it. In all cases, the beads stored in bulker bags were stored within racks or on the floor in well ventilated areas. The ventilation primarily provided by buildings with high ceilings and large door openings into the buildings.

Pre-foaming EPS beads

All the manufacturing sites were aware of the hazardous area located around the bead hopper where the beads are generally dropped into it by gravity (cutting open the bottom of the bag). In three workplaces the pentane gas/steam exhaust from the prefoamer was seen to be venting within the building. Improvement notices were issued to these premises to exhaust the gas/steam mixture outside the building away from ignition sources to a safe location and avoiding any accumulation of vapours. Two workplaces which had portable gas detectors stated that the equipment alarmed when located close to the EPS bead bags and the prefoaming equipment. Demarcation of the areas where flammable gas may accumulate would be an additional aid to ensure ignition sources are not introduced in those areas or done so only under a hot work permit system.

Maximum pentane vapour production occurs in the prefoaming stage, and guidance material recommends that the exhaust gasses from this process be exhausted outdoors. In most cases the hopper and the prefoamer were seen to have earthing connections on the equipment. In only one instance was the EPS bead bag bonded to the hopper with an earthing strap. The main concern

with earthing and bonding of equipment at all workplaces was a lack of testing and verification that the earthing system is functioning correctly. In most cases there were no routine checks to verify that the static control provided by the earthing system is functioning properly. At the two workplaces that stated that earthing is being checked, there was no documentary proof to validate this. PCBUs should periodically verify the effectiveness of their earthing and bonding systems (i.e. confirm electrical continuity) and ensure these are maintained (e.g. visual/physical inspection at an appropriate frequency). Effective earthing and bonding is a critical control measure within the polystyrene manufacturing industry which needs to be functioning correctly at all times.

Storage hoppers and bead transfer ducts
In all cases except at one workplace, the expanded beads are stored to mature in ventilated mesh fabric silos with earth straps connected both to the silos and transfer pipes. The metal silos in one site appeared to be fit for purpose with the earthing controls and appropriate ventilation provided within the silo. The lack of validation that the earthing system remains fit for purpose was also identified as an issue here.

Product or block and product moulding machines
Across the workplaces, the processing equipment varied in age and throughput capacity. In some instances machines were reaching the end of their working life and are being replaced progressively. The main issues noted was the noise that is created during parts of the manufacturing cycle. In many cases there was a mandatory requirement to wear hearing protection in the vicinity of the moulding machines, but this was not the case at all sites. It is recommended that sites that are currently not enforcing hearing protection requirements to conduct some baseline noise monitoring to demonstrate that the noise exposure standards are not exceeded.

Block conditioning and drying
Six sites that manufacture polystyrene blocks kept them in ovens to dry. Drying ovens are normally kept at 70^{o}C where the blocks have hot air introduced at a low level and exhausted at the roof of the oven. Due to the airflow, it is unlikely that flammable vapours can accumulate within the oven. The main concern is having a lone worker accessing the oven when placing or removing blocks. At two workplaces there were emergency alarms and lights that would activate after a set period if the worker does not exit the oven in a predetermined time. Polystyrene manufacturers that have ovens that are operated by lone workers need to have appropriate engineering controls in place to alert workmates or the PCBU if something untoward were to happen.

For those workplaces without ovens, the blocks were stored in generally well ventilated areas with little likelihood of flammable vapour build up. In all cases the movement of the bulky blocks pose manual handling hazards. In many cases customised trolleys or fork lift grabs have been developed to cater for the bulky load.

Hot wire table and block cutting
All workplaces involved in cutting blocks have hot wire cutting machines with electrical isolation utilising residual current device (RCD) safety switches. Hot wire cutting of polystyrene foam may generate thermal decomposition products. The type and concentration of these decomposition products are dependent on factors including wire temperature, cutting rate, block size and foam density. Cutting operators should be located in a well-ventilated area. A number of machines were observed to have had local exhaust ventilation systems available close to the cutting wires for capturing cutting fumes. Local exhaust ventilation systems can be effective at removing fumes from within the workplace, but their performance should be verified to ensure that they are working effectively.

Legislative risk controls

Workplace register
All workplaces inspected maintained a site register and SDSs. In one case a SDS was over five years old which exceeds the maximum review period. SDS must be dated less than five years as prescribed by the WHS Regulation. In some cases a documented risk assessment procedure was conducted prior to receiving a ‘new’ chemical on site which is good industry practice.

Placards and signs
In a number of instances, package storage areas including LPG stores exceed the placard quantity, thus requiring placards to be placed adjacent to the storage area and an outer warning 'HAZCHEM' placard placed at the main entrance to the workplace. As discussed previously, under the WHS Regulation, Class 9 EPS bead is not considered to be a hazardous chemical (unlike the generated pentane which is). It is prudent to ensure that relevant safety signs are maintained for the provision of safety information for the benefit of staff, visitors and the emergency services. There were some deficiencies noted with faded safety signs at several workplaces. Site inspections with a prompting checklist could assist in ensuring that issues like safety signage is properly maintained.

Ignition sources
The flammability hazards of pentane were well understood by all the PCBU's. In most instances static electricity controls were evident on the machinery and ducts. EPS is an electrical insulator where electrical charge build up can result in a potentially dangerous situation. Uncontrolled electrostatic discharge can ignite a flammable mix of pentane vapours in air. Prevention of an uncontrolled discharge significantly reduces the chances of a flash fire. Appropriate electrical bonding and grounding of processing and handling equipment help to prevent charge accumulation and a sparking discharge. Qualified electricians should conduct periodic testing of bonding and grounding systems to ensure their effectiveness is maintained.

An improvement notice was issued at one workplace where earthing could not be verified. Procedural controls such as preventing smoking within the work area appeared to be managed well. Isolation and hot work permit systems were found to be absent at several workplaces. With the known flammability hazard it is essential that systems are in place to control potential ignition sources. Passive controls such as earthing straps must be fit for purpose and maintained to ensure they continue to function correctly. An assurance of this can be provided by regular inspection and periodic testing. Retaining records of these activities will help to demonstrate this assurance.

Managing spills
All workplaces had systems in place to prevent polystyrene beads from entering the storm water system. Sites that stored hazardous chemicals had appropriate bunded compounds and clean up kits.

Fire fighting
As there is no Australian Standard for the manufacturing of polystyrene products, there is no specific fire fighting requirements prescribed that are available. The Building Code of Australia (BCA) prescribes fire fighting for general industrial buildings. Risk assessments and SDS information suggest that appropriate fire fighting extinguishers to be located adjacent to the risk. This was evident in most cases.

Inappropriately locating block polystyrene, finished goods or waste blocking off access to fire safety equipment was observed in some instances and required immediate attention by the workplace to correct the situation and ensure clear access is re-established and maintained. The equipment itself was generally maintained according to Australian Standard AS 1851 except in one case where out-of-date equipment was observed.

A number of sites did not conduct any practical fire fighting training. It is suggested that all operational staff be provided with practical fire extinguishment training. Familiarity and confidence in undertaking early intervention actions can prevent a small fire rapidly turning into a big fire.

Risk management and general safety obligations
To successfully manage risk at any workplace, a number of issues need to be addressed. The starting point is hazard identification, followed by determining and implementing appropriate risk control measures. The process must consider the hierarchy of controls, with elimination of the risk considered where possible followed by substitution or isolation. If this is not possible, then engineering control should be implemented in preference to procedural controls. The engineering

controls need to be maintained which may require maintenance schedules and inspection and maintenance procedures to be developed.

Procedural controls such as documented safe work procedures need to be developed for routine tasks. For non routine tasks, other systems such as job safety analysis (JSA), hot work permit and isolation systems need to be developed. If an incident were to occur systems need to be in place to mitigate the risk such as a functional fire safety system, emergency shut down procedures and an emergency plan.

Appropriate induction, training and supervision must also be provided and training records maintained. Similarly equipment maintenance must be recorded and maintained. The workplace must also have an auditing system in place to validate everything is operating as it should, if not, a corrective action system, incident investigation system and records management system needs to be operating. The various elements must interact with each other to have an effective safety management system (SMS).

Of the 11 workplaces audited, four sites appeared to have a well developed and functional SMS. Six workplaces had some of the elements in place and others were continuing to develop the systems as a 'work in progress'. One workplace lacked any documentation to help verify the safety systems. These findings lead to various enforcement approaches being applied including notices and/or development of improvement plans incorporating specific timeframes for specified activities.

The inspectors reiterated the advantages of having documented systems in place. Advantages include: being able to demonstrate how decisions about controlling risks were made, assist training of new staff; provide for safe work procedures; assists in assurance of safety and helps demonstrate this to others (regulators, customers, insurance agents).

Developing and maintaining systems takes time and resources. It is important that the PCBU recognises this, and allocates tasks and time to develop and maintain safety systems.

Housekeeping and combustible dusts

The general level of housekeeping at all sites was good except for one site where their vacuum cleaner broke down the day before the audit which allowed build up of dust within the workplace floor. It was also noted that there was some build up of polystyrene dust on the higher level metal girders which are generally inaccessible.

This highlighted the issue of combustible dust hazards. Good housekeeping should be employed throughout the work area to limit the build up of dust that may be generated during manufacturing processes. Dust collected from cutting and grinding operations should be collected and removed. All potential ignition sources must be strictly controlled in areas where combustible dust clouds might form.

It is suggested that attention is paid to this hazard and PCBUs review their management of combustible dust hazards (e.g. determine appropriate frequency of cleaning ensuring hidden or out-of-sight areas where dust may accumulate are included).

Emergency plans

Site emergency plans were available at all the sites inspected. In most cases they covered the evacuation routes and muster points. Some sites had more detailed plans specifying specific tasks and functions of staff members during an emergency. It is important that any specific actions that need to be carried out during an emergency are documented and tested. For example, if there is a specific shutdown sequence for machinery or boilers, or the location of isolation points etc. should be documented. A documented emergency plan can be a useful document for training or inducting staff. Regular drills should be conducted to test and revise the plan in the light of any short comings.

Where to from here?

The program has revealed that there are opportunities for those workplaces that process polystyrene beads to make improvements in their safety management systems. Assurance of safety at the workplace and demonstrating compliance with the WHS Act and Regulation will be enhanced by having documented risk assessments, safe work procedures, job safety assessments, staff training matrix and records, emergency procedures, inspection check sheets, maintenance schedules and records, change management system and a document control system. It is important to consider health and safety issues as core business and allocate resources and time to the tasks to manage safety.

It is important that the businesses have a good understanding of the hazards and the controls in place to control those hazards at the workplace. The controls must then be validated to ensure they are working correctly. Engineering controls by regular testing, inspection or maintenance and administrative controls by regular observations and review. Maintaining appropriate records provides evidence of application of the various elements of the safety system. Those workplaces which have comprehensive systems in place must continue to monitor and review these. Those workplaces that are not yet fully developed need to ensure that continual improvements are made to achieve comprehensive safety systems.

The relevant industry association/s should consider the content of this report and identify gaps in existing industry guidance and develop further guidance as required. WHSQ will continue to work with the industry to achieve improved safety and legislative compliance via ongoing monitoring programs and continued participation in various consultation and engagement processes with industry.

WHSQ wishes to acknowledge the overall positive interactions with operators and workers within the EPS bead manufacturing industry involved in this program.