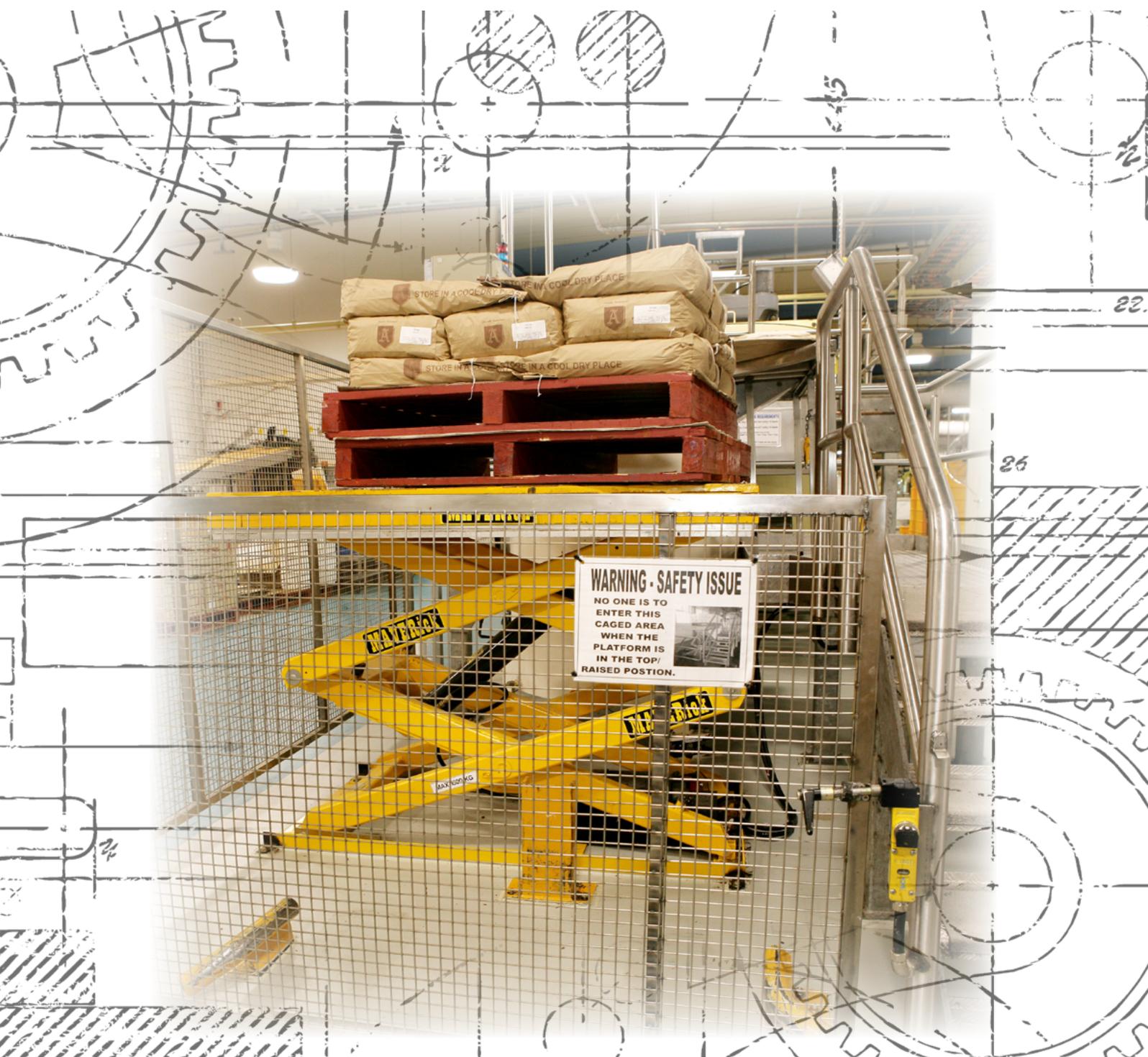


Work-related fatalities associated with unsafe design of machinery, plant and powered tools, 2006 – 2011



November 2014



safe work australia

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Case study

A casual factory hand was required to assist in the operation of the Porterman plant. The Porterman plant makes cardboard boxes. Its overall size is approximately 7.5 metres in length and 4.5 metres wide. The rotation speed of the rollers varies between 40 and 80 RPM. For at least one particular job, which was done on average once a month, the conveyor arm of the Porterman plant was raised up at a 90 degree angle. Raising the conveyor arm creates a space of approximately 600mm between the out feed rollers of the two colour printer, slotter and stacker machine and the bed of the out take conveyor leading to the stacker at the end of the line. This allowed bodily access to the moving out feed rollers of the Porterman plant. The machine continued to operate and the rollers continued to move while the cardboard product pieces were removed from this location and stacked onto a pallet. On this day, the worker had moved into the space between the out feed rollers of the two colour printer, slotter and stacker machine and the raised arm of the out take conveyor, probably to remove cardboard pieces that had exited through the out feed rollers. His clothing was caught on an out feed roller and his body was dragged over the top of the roller as its revolution proceeded clockwise. Another employee heard a scream and a 'big' noise, pushed the emergency stop button and ran to the space between the out feed rollers and the raised arm of the out-take conveyor. An ambulance attended, along with the Metropolitan Fire Brigade. The worker was trapped in the rollers of the machine for approximately 45 minutes until he was released and taken by ambulance to hospital. He died the following day. No hazard identification had been undertaken prior to commissioning this plant. Emergency stops were not properly labelled and there was inadequate information, instruction training and supervision. Guarding was later installed and the conveyor was interlocked so that the rollers could not operate if the conveyor was in the "up" position at a cost of about \$6000.

Summary

This study examined 639 work-related fatalities that occurred over the period 2006 to 2011 and involved machinery, plant, and powered tools, with the purpose of assessing the extent to which unsafe design contributed to the fatal incident. Of these fatalities, there was sufficient information available on the circumstances of the fatality to be able to make a judgement on the contribution of unsafe design for 523 fatal incidents. Of these, 63 fatalities (12%) were determined to have been either definitely caused by unsafe design or design-related factors clearly contributed to the fatality. A further 125 fatalities (24%) were considered possibly design-related: these included incidents where the circumstances suggested that unsafe design played a role or were incidents that might have been prevented had existing safety technology been used. The remaining 335 fatalities (64%) were determined to be unrelated to unsafe design.

Overall, 36% of fatalities (188) that fell within the study scope, and for which the design-relatedness could be determined, were assessed to be definitely or possibly design-related. These incidents were coded to a circumstance category that best summarised the broad circumstances of the incident.

The most common circumstance categories were:

- » Inadequate guarding — 21% of design-related fatalities
- » Lack of roll-over protection structures / seat belts — 15%
- » Lack of residual current device — 12%
- » Lack of interlock — 8%, and
- » Driver obstructed vision — 8%.

Although this report highlights many aspects of unsafe design across many types of machinery and plant, there were some distinct groupings of incidents that clearly highlight some common hazards.

There were 28 work-related fatalities where the design-related issue identified was Lack of roll-over protection structures / seat belts. Most of these fatalities involved roll-overs of tractors or quad bikes — both well-known issues that have received considerable attention in the past — in the case of tractors — and currently — in the case of quad bikes.

Less well-known is the number of fatal incidents involving the users of elevating work platforms being crushed against roofing and beams. There were 7 fatalities during the period 2006 to 2011. Some manufacturers are responding to this risk with caged platforms with anti-entrapment devices such as a frame fitted to the basket that provides a 'safe zone' within the platform and sensor bars or pads that stop the movement of the basket should the operator be pushed onto them.

At the broadest level the same conclusions can be drawn from this study as were drawn in an earlier study in 2005 (ASCC, 2005).

- » unsafe design is a significant contributor to fatal incidents in many industries
- » there are many commonalities in the circumstances of the fatal incidents, and
- » there are existing solutions for most of the common identified design-related problems.

Introduction

Safe design and the Australian Work Health and Strategy

The Australian Work Health and Safety Strategy 2012–2022 is directed at fulfilling the vision of Australian workers having “healthy, safe and productive working lives”. As well as setting targets for reducing the national incidence of work-related injury, disease and fatality, the Strategy states seven national action areas, the first of which is “Healthy and safe by design”.

Action Areas	Strategic Outcomes	
Healthy and safe by design	Hazards are eliminated or minimised by design	<ul style="list-style-type: none">» Structures, plant and substances are designed to eliminate or minimise hazards and risks before they are introduced into the workplace.» Work, work processes and systems of work are designed and managed to eliminate or minimise hazards and risks.

Safe design — a broad concept

This report is primarily focused on the design-related aspects of fatal incidents involving specific categories of machinery, plant and tools. However, the concept of safe design should be considered a broad continuum that includes not only the tools but also the design of the workplace itself, how workers utilise that space, and how the arrangement influences the way tasks are undertaken. Conceptualising safe design in this way shows that safe design should be an intrinsic consideration when examining both the tools associated with a task, the environment in which the task is carried out and the process by which the task is undertaken.

Safe design — an emphasis on passive safety

In most work situations there are many different ways a task or process could be carried out to minimise the risk of harm to the worker.

A safe system of work requires clearly documented procedures that are based on a systematic examination of the tasks involved and the potential hazards identified. Although this report is primarily focused on the industrial design-related aspects of fatal incidents, in nearly all these incidents the fatality might have been avoided if the workplace had better work systems that were closely adhered to. However, safe procedures generally only work if they are closely followed by the worker.

The best methods of protecting workers are passive — those that protect from harm, or decrease the likelihood of injury, with no input from the worker. Therefore, the most effective way to deal with hazards is to eliminate them, and in many situations this can be achieved by implementing design changes to the machinery, plant or tools.

Examples of passive safe design include guarding to protect a worker from the risk of entrapment; shielding to protect from projectiles; interlocks that shut systems down should guarding or shielding be removed for maintenance or cleaning; lockout systems that protect a worker conducting maintenance on machinery from inadvertent start up by another worker; roll-over protection structures on vehicles; and residual current devices that shut off power supply when earth leakage is detected.

Safe design — previous research findings

This report is based on a similar methodology used in two previous reports, one covering the period 1989 to 1992 (NOHSC, 2000), and the other covering the years 2000–01 and 2001–02 (NOHSC, 2004 and ASCC, 2005).

The earlier study covering the period 1989 to 1992 looked only at fatal incidents involving *Machinery and (mainly) fixed plant*. The authors determined that of the 225 incidents examined, 117 (52%) had at least one design factor contributing to the fatal outcome.

The 2000–01 to 2001–02 study had a broader scope — not restricted to specific agencies — and found that of the 167 fatal incidents for which adequate information was available, 106 (63%) were definitely, probably or possibly design-related.

This study was based on 639 work-related fatalities that involved machinery, plant, and powered tools (see scope details on the next page) and occurred over the six-year period 2006 to 2011. Of these, 523 fatal incidents had sufficient information available to make a design-relatedness assessment, and of those, 188 (36%) were definitely or possibly design-related.

Despite the differing scopes, this result suggests there has been some improvement since the early 2000s and clearly highlights the significant impact unsafe design still has on worker safety. However, because of limited information on many incidents, the different scopes, and the often subjective judgements involved, the proportions presented here should be considered indicative of the scale of the issue rather than a precise measure.

Safe design — the impact of regulatory changes

One way to help protect workers from injury is to develop enforceable standards that employers must meet to protect their employees from harm in the workplace. Current model legislation and codes of practice emphasise the concept of duty of care that extends through the ‘chain of command’ and externally to suppliers and contractors. At the practical level this means that “Designers have a duty to ensure, so far as is reasonably practicable, that the plant is without risks to health and safety to workers throughout the life of the plant” (SWA, 2012b).

A specific example of regulation enforcing passive safety and reducing fatalities is the introduction in 1994 of a new standard for plant that included roll-over protection structures (ROPS) on tractors. The standard was implemented differently by each of the states and territories in Australia and at different times. A Safe Work Australia study on tractor-related fatalities found that the number of workers killed due to the tractor roll-overs decreased from 40 deaths in the 1989–92 period to 17 in the 2004–07 period (SWA, 2011a).

Safe design — technological innovations

Undoubtedly modern digital technology has become more sophisticated and affordable and increasingly will be incorporated into industrial design to improve communication, monitoring, control and remote operation. Common applications already include closed-circuit rear-vision cameras to improve safety when reversing trucks and other plant; proximity detectors to warn drivers of overtaking vehicles; and stability control systems for cars and trucks. This study includes many fatalities that might have been prevented if such technology had been in use.

Study methodology

The data source for this study is a sample of work-related fatalities, drawn according to the scope described below, from Safe Work Australia's Traumatic Injury Fatality Collection which includes all work-related fatalities of both workers and bystanders. For each fatality all available information was re-assessed to determine whether or not the fatal incident was related to unsafe design. The main sources of information were incident narratives supplied by jurisdiction work health & safety (WHS) authorities and Coroner's and police reports held in the National Coronial Information System (NCIS). Prosecution information published on WHS jurisdiction websites was also searched and matched where possible. On the basis of the information available the fatalities were assessed as either definitely design-related, possibly design-related or not design-related (see Definitions section). Where the fatality was considered design-related, the occurrence was assigned to a broad circumstance category, such as Inadequate guarding. Where there was insufficient information about the fatal incident to make an assessment, the data-item was recorded as unknown.

Despite having access to information held in the NCIS, the overall quality of information available was often poor. The ideal source of information for this study would be WHS investigator's reports. WHS investigations are generally carried out with full access to the scene of the incident by personnel that have a reasonable knowledge of the plant/tools involved and the process that was being carried out. However, in most cases jurisdictions could not release this information for privacy and legal reasons — primarily in case it hinders prosecution. For some fatal incidents summaries of these reports can be found in prosecution and Coroner's reports.

Study scope

The scope of this report is restricted to work-related fatalities (including bystanders) where the Type of Occurrence Classification System (TOOCS) Breakdown agency codes were *Machinery and (mainly) fixed plant, Self-propelled, Semi-portable and Other mobile plant, Powered equipment, tools and appliances, and Ladders, mobile ramps and stairways, and scaffolding.*

The Breakdown agency is intended to identify the object, substance or circumstance that was principally involved in, or most closely associated with, the point at which things started to go wrong and that ultimately led to the most serious injury or disease.

The scope excludes fatal incidents that occurred on public roads.

» Group 1: Machinery and (mainly) fixed plant

* *This group includes a very wide range of manufacturing and processing machinery including those that cut, slice, saw, crush, roll, heat, cook, cool, lift, fill and package.*

» Group 2: Mobile plant and transport — Self-propelled, Semi-portable and Other mobile plant only

* *This group includes self-propelled plant such as harvesters, mining plant, graders; bulldozers, excavators, front-end loaders and road rollers; Semi-portable plant such as roof bolters, pneumatic tools, compressors, pumps and cement mixers; and other mobile plant such as tractors, ploughs, drilling rigs, mowers, wheelbarrows and trolleys.*

- » Group 3: Powered equipment, tools and appliances
 - * *This group includes a wide range of equipment including workshop tools, kitchen appliances, office equipment, and gardening equipment.*
- » Group 4: Non-powered handtools, appliances and equipment
 - * *Limited to Ladders, mobile ramps and stairways, and scaffolding only*

Definitions

The following definitions were used as a guide when assessing the information available for each fatality.

Design-related

A fatal work-related incident was considered design-related if any aspect of the construction (in its current state) of equipment, plant, tools or structure involved in the incident was implicated in the occurrence of the fatal injury and it was realistic that the aspect could have been modified to avoid the occurrence of the fatal injury.

Definite

Clear implication of design issues was mentioned or implied in the information sources.

Possible

Design-related issues were not implicitly stated but the available information suggested design was an issue.

Fatalities that might have been prevented by currently available safety measures such as residual current devices, roll-over protection structures, rear-vision camera systems, elevating work platform crush protection cages, vehicle park brake lockout or warning systems, and fixed fall protection were included in this category.

This retrospective approach may be considered unrealistic since some of the safety measures might not have been commonly used or commercially available when the machinery or vehicle was manufactured. However, the underlying principle is that in most cases it would be practical to incorporate these technologies into older machines to meet current safety standards.

Lack of personal protection equipment (PPE) was generally considered a work systems issue rather than a design issue, unless the PPE caused a fatal incident because of poor design.

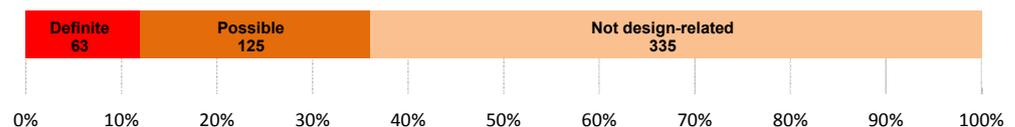
Not design-related

A fatal work-related incident was considered not design-related when there was sufficient information to establish that design issues did not play a part in the incident.

Study results — a broad overview

There were 639 work-related fatalities over the period 2006 to 2011 that fell within the scope of this study. Of these, 63 fatalities (10%) were determined to have been either definitely caused by unsafe design or design-related factors clearly contributed to the fatality. A further 125 fatalities (20%) were considered possibly design-related: these included incidents where the circumstances suggested that unsafe design played a role or were incidents that might have been prevented had existing safety technology been used. There was insufficient information available to classify 116 fatalities (18%). The remaining 335 fatalities (52%) were determined as unrelated to unsafe design.

The significance of the proportion of definite and possible design-related fatalities is constrained by the subjective nature of some of the 'possible' categorisations and the 18% of fatalities for which the design-relatedness could not be determined. However, excluding the unknown category from the calculation effectively pro-rates these deaths across the remaining categories. On this basis, 36% of fatalities that fell under the study scope and for which the design-relatedness could be assessed were determined to be definitely or possibly design-related.



Based on the available information, each of the 188 fatal incidents that were considered design-related was assigned a broad circumstance category that best described the main design-related aspect of the fatal incident. Table 1 shows the number of fatalities in each design-related circumstance category. The most common design-related circumstance category, implicated in 40 fatalities, was Inadequate guarding. Lack of roll-over protection structures / seat belts was implicated in 28 fatalities; Lack of residual current device was implicated in 22 fatalities; Lack of interlock was implicated in 15 fatalities; and Driver obstructed vision was also implicated in 15 fatalities. These five categories together accounted for almost two-thirds (64%) of all identified design-related fatalities.

Although the fatal incidents were coded to a single design-related circumstance category, there was considerable overlap in many cases. For example, the removal of guarding or interlock mechanisms on a machine or vehicle was categorised under Unapproved modification since it is useful to identify these occurrences rather than include them under the relevant category. In addition, guarding and interlock mechanisms are often used together to protect workers from entrapment and entanglement in machinery.

Table 1: Design-related work-related fatalities: circumstance category by confidence category, 2006 to 2011 combined

Circumstance category	Confidence category		Total
	Definite	Possible	
Inadequate guarding	15	25	40
<i>Inadequate guarding — other</i>	15	18	33
<i>Inadequate guarding — elevating work platform crushing</i>	0	7	7
Lack of roll-over protection structures / seat belts	10	18	28
Lack of residual current device	6	16	22
Lack of interlock	5	10	15
Driver obstructed vision	3	12	15
Malfunctioning / failed equipment	6	6	12
Unapproved modification	6	5	11
Inadequate fall protection	5	5	10
Poor control layout	2	7	9
Runaway vehicle / park brake	0	8	8
Lack of high tension proximity detector	0	2	2
Lack of smoke / fire detection	0	1	1
Other circumstances	5	10	15
Total	63	125	188

The following section examines the fatal incidents underlying these broad circumstance categories and provides brief narratives of some of the incidents and comment around some of the design-related issues.

Circumstance category

Inadequate guarding

Hazardous machinery that could trap or entangle a worker in any way should have some form of guarding to minimise that risk. This study found that Inadequate guarding was the most common circumstance category of incident, encompassing 40 fatal incidents and involving a large variety of vehicles and machinery. Table 2 shows a breakdown of the types of vehicle or machinery involved in the fatal incidents.

At an aggregate level, 11 fatal incidents coded to Inadequate guarding involved Conveyors and lifting plant; 10 involved Vehicles; 6 involved Crushing, pressing and rolling machinery; and 4 involved Cutting, slicing and sawing machinery.

Table 2: Design-related work-related fatalities: Inadequate guarding circumstance category by confidence category, 2006 to 2011 combined

Type of vehicle or machinery involved	Confidence category		Total
	Definite	Possible	
Conveyors and lifting plant	2	9	11
<i>Elevating work platforms</i>	0	7	7
Vehicles	4	6	10
<i>Tractors</i>	3	3	6
<i>Forklifts</i>	0	2	2
<i>Dozers</i>	0	1	1
<i>Gokarts</i>	1	0	1
Crushing, pressing and rolling machinery	3	3	6
Cutting, slicing and sawing machinery	1	3	4
Other mobile plant — <i>Hay balers</i>	0	2	2
Semi-portable plant	2	0	2
Garden and outdoor powered equipment	0	1	1
Electrical installation	1	0	1
Heating, cooking and baking equipment	1	0	1
Workshop and worksite tools and equipment	0	1	1
Filling and bottling / packaging plant	1	0	1
Total	15	25	40

Underlying the aggregate groups are two distinct clusters of incidents that highlight the dangers involved in using elevating work platforms and tractors.

Elevating work platforms

There were 7 fatal incidents involving elevating work platforms where the workers were trapped or crushed against an overhead obstacle such as a roof or beam. The issues surrounding this type of incident have been highlighted by researchers in the United Kingdom (HSE, 2013). The incidents were classified as ‘possibly’ design-related because the incidents might have been prevented by modifications that have only recently been developed and adopted by some manufacturers.

Two of the incidents are briefly described below:

- » A worker was crushed when he was trapped between the basket of an elevating work platform and an overhead beam in the machinery shed of a farm.

- » A worker operating an elevating work platform collapsed onto the controls, which caused the platform to rise and pin him against a beam.

There are currently two primary types of 'anti-entrapment' devices or modifications available: a frame fitted to the basket that provides a 'safe zone' within the platform, and sensor bars/pads that stop the movement of the elevating work platform should the operator be pushed onto them.

Tractors

There were 6 incidents involving tractors where inadequate guarding resulted in a fatal incident. Of particular note are 3 fatalities caused by clothing becoming entangled in the power take-off coupling (PTOs). These incidents are briefly described below:

- » Three fatal incidents occurred under similar circumstances when the worker's clothing became entangled in PTOs: *this is a common and acknowledged farming hazard and inexpensive guarding is readily available and easily fitted.*
- » A worker's leg became trapped in a grain auger that was being powered through a tractor PTO: *this is also a common and acknowledged hazard with many published guides to guarding the grain intake with mesh grills.*
- » A hay bale rolled off the tractor front end loader bucket down the arms and onto the operator: *safety guides recommend the use of a hay spike or clamps designed to move round bales and the tractor should have been fitted with a falling object protective structure (FOPS) to safely conduct this task.*
- » A worker stepped off their tractor in front of the rear wheel and the tractor rolled forward over him: *further information was not available to identify why the tractor rolled forward, though a safe access platform can eliminate the risk of alighting from a tractor into the path of the rear wheel.*

As well as the clear cluster of incidents involving elevating work platforms and tractors, there were also 2 incidents involving forklift trucks and 2 involving hay bailers where the circumstances were, respectively, similar.

Forklifts

- » A worker's head and upper torso was trapped between the horizontal crossbars of the cascading inner and outer mast of the hydraulic lifting mechanism of a forklift as the tines were lowered.
- » A worker became trapped between the front chassis and forks of the forklift he was operating. He had accidentally fallen while leaning forward through the front frame of his forklift to remove a string from the bottom of a bag. While struggling he reached behind and knocked the tilt mechanism control lever causing the forks to tilt forward and further increase the pressure on his body:

Forklift manuals and safety publications highlight that the operator should not place any part of the body through the front frame at any time so this incident is primarily due to operator error. However, this hazard could perhaps be eliminated by some form of collapsing guard or screening.

Hay balers

- » Two fatal incidents occurred under similar circumstances when workers were entrapped in hay balers while clearing blockages: *safety advice emphasises that the tractor should be turned off and the key removed and brakes or chocks applied before dealing with baler blockages, but possibly more safety features could be designed into balers to make this a more passive safety system.*

The remaining 23 fatal incidents coded to Inadequate guarding involved a wide variety of machinery and tools and had few commonalities beyond their classification. However, to highlight some of the circumstances of the fatal incidents a brief narrative and comment around the 3 ‘definite’ design-related incidents that involved Crushing, pressing and rolling machinery are listed below.

Crushing, pressing and rolling machinery

- » A worker’s clothing caught on rollers and dragged him into a printing slotter machine [used to make cardboard boxes]: *the prosecution summary stated that “no hazard identification had been undertaken prior to commissioning this plant. Emergency stops were not properly labelled and there was inadequate information, instruction training and supervision. Guarding was later installed and the conveyor was interlocked so that the rollers could not operate if the conveyor was in the “up” position”.*
- » A worker was entrapped between a rotating tube ball mill and its chassis: *the initial police and WorkSafe inspection highlighted the obvious hazardous nature of the machine and the lack of guarding.*
- » A maintenance fitter measuring a pipe bending machine was struck on the head by the travelling mandrel carriage. The machine had been turned on by the machine operator: *the prosecution summary states that the existing guard fence and laser scanner on the pipe bending machine were inadequate in that they failed to prevent undetected access to parts of the machine. In addition, the company also failed to ensure there was an adequate tag and lockout procedure in place.*

Lack of roll-over protection structures / seat belts

The Lack of roll-over protection structures (ROPS) and seat belts was a quite specific circumstance category encompassing 28 fatal incidents that primarily involved quad bikes and tractors — nearly all the incidents occurred on farms. Table 3 shows a breakdown of the types of vehicle involved in the fatal incidents.

At an aggregate level, 13 fatal incidents coded to Lack of roll-over protection structures / seat belts involved quad bikes and 11 involved tractors. The remaining single incidents involved a road roller, a buffalo catcher, a three-wheeler bike, and a front-end loader.

Table 3: Design-related work-related fatalities: Lack of roll-over protection structures / seat belts circumstance category by confidence category, 2006 to 2011 combined

Type of vehicle involved	Confidence category		Total
	Definite	Possible	
Quad bikes	2	11	13
Tractors	6	5	11
Road roller	0	1	1
Buffalo catcher	1	0	1
Three-wheeler bike	0	1	1
Front-end loader	1	0	1
Total	10	18	28

Of the 13 fatal incidents involving quad bikes, 11 were clearly the result of the worker being pinned under the heavy quad bike — precisely the circumstance roll-over protection might have prevented. The incidents clearly highlight the hazard of using quad bikes on sloping ground, especially when attachments, such as spray tanks, are added. Furthermore, in 5 of the 13 incidents, records show that the deceased had not been wearing a helmet, no mention was found for the remaining 8 incidents. However, the lack of PPE itself is not a design issue but a work systems issue.

Brief narratives of three of the quad bike roll-over incidents are presented below:

Quad bikes

- » A quad bike being used for spraying rolled over while traversing sloping terrain and trapped the rider under the bike.
- » A quad bike became unbalanced and rolled on top of the rider while riding around or through a drainage ditch.
- » A quad bike rolled over onto the rider when a front wheel struck a fence while mustering cattle.

There were 11 fatal incidents involving tractors where the design-related circumstance category was Lack of roll-over protection structures / seat belts. Of these incidents, 8 occurred on steep slopes or when the tractor was accidentally driven over embankments. These incidents all involved old tractors that had no roll-over protection structures or seat belts. In 1994 a new standard for plant that included roll-over protection structures (ROPS) on tractors was introduced. The standard was implemented differently by each of the states and territories in Australia and at different times. When introduced, the installation of ROPS and seat belts was made compulsory on new tractors, old tractors built after 1981, and used tractors when sold or leased. However, although retrofitting of ROPS on older tractors on private farms without employees was encouraged with rebates, installation was not compulsory unless the farm had employees (SWA, 2011a).

Brief narratives of three of the fatal incidents are presented below:

Tractors

- » A worker was slashing grass on a steep and unstable section of a paddock and collided head on with a hidden tree stump. The tractor subsequently rolled and was not fitted with ROPS or a restraint for the operator.
- » A worker was spraying blackberries from his tractor on steep terrain when the tractor rolled over and pinned him underneath. The tractor was not fitted with ROPS or a seat belt.
- » A worker died when his tractor rolled down a creek embankment while slashing grass. The tractor was about 40 years old and had no ROPS.

Lack of residual current device

A residual current device (RCD) can shut off power in milliseconds when it detects any leakage to earth. In most situations this would prevent a person being electrocuted should they inadvertently form a bridge between a live wire or appliance and earth. In many situations it is mandatory to install RCDs. For example, the model code of practice for managing electrical risks in the workplace (SWA, 2012a) requires that “a person conducting a business or undertaking must ensure, so far as is reasonably practicable, that any electrical risk associated with the supply of electricity to ‘plug in’ electrical equipment is minimised by the use of an appropriate RCD in certain higher-risk workplaces”. The devices can be installed at the switchboard, on individual power points and on extension leads and power boards.

The 22 fatalities shown in Table 4 might have been avoided if RCDs had been installed in the power circuit that these workers came into contact with. For the 16 fatal incidents considered ‘possibly’ design-related it is assumed that no RCD was fitted. For the 6 ‘definitely’ design-related incidents, records highlighted the lack of RCD protection. The table shows that other than fixed wiring, the type of equipment that caused the fatal incident was quite varied. In some cases the incidents involved an electrician deliberately working on live wiring or machinery.

Table 4: Design-related work-related fatalities: Lack of residual current device circumstance category by confidence category, 2006 to 2011 combined

Type of equipment or appliance involved	Confidence category		
	Definite	Possible	Total
Fixed wiring	2	7	9
Lighting equipment	0	2	2
Pump	1	1	2
Solarwater heater	0	1	1
Ride-on mower	1	0	1
Control apparatus	0	1	1
Elevating work platforms	0	1	1
Air conditioning unit	0	1	1
Beverage bottling plant	0	1	1
Dishwasher	1	0	1
Arc welding equipment	1	0	1
Angle grinder	0	1	1
Total	6	16	22

The circumstances around the fatal incidents were as varied as the types of equipment involved.

Brief narratives of three incidents are presented below:

Electrocutions

- » An unlicensed worker damaged wiring during a bathroom renovation and attempted to make a repair while it was still live.
- » An electrician was fixing a rooftop solar hot water system he thought was isolated. The circumstances suggest that another person turned the power back on without the electrician’s knowledge.
- » A worker came in contact with a live metal pipe on a hydraulic pump. The pump had an incorrectly wired three-phase plug.

Lack of interlock

All hazardous machinery and plant should be designed with interlock mechanisms to eliminate the risk of the machinery or plant being accidentally turned on while using, cleaning or carrying out maintenance. This can be achieved by sophisticated fail-safe systems or by simply locking the controls or power source and taking control of the only readily accessible key.

Table 5 shows that the 15 fatal incidents coded to Lack of interlock involved a broad variety of vehicles and machinery. However, three of the incidents involving vehicles occurred under similar circumstances since the drivers were struck by their own vehicles when they started them from outside their cab while the vehicles were still in gear. In addition, two fatal incidents occurred while using Cotton module builders — large bins with a sliding hydraulic press that compresses newly picked cotton into bales or modules.

Table 5: Design-related work-related fatalities: Lack of interlock circumstance category by confidence category, 2006 to 2011 combined

Type of vehicle or machinery involved	Confidence category		Total
	Definite	Possible	
Vehicles	2	3	5
<i>Truck</i>	0	1	1
<i>Car carrier</i>	0	1	1
<i>Cement mixer</i>	1	0	1
<i>Back hoe</i>	0	1	1
<i>Tractor</i>	1	0	1
Crushing, pressing and rolling machinery	2	2	4
<i>Cotton module builder</i>	1	1	2
Conveyors and lifting plant	0	2	2
Filling and bottling / packaging plant	0	2	2
Other plant & machinery	1	1	2
Total	5	10	15

Brief narratives and comments on the 5 ‘definite’ design-related fatal incidents associated with Lack of interlock are presented below:

Cement mixer

- » A worker fell into the cement mixer he was cleaning out with a hose: *the prosecution summary stated that the worker had removed a guard that was not secured and there was no interlocking mechanism to stop the operation of the mixer in the event that the guard was removed.*

Cotton module builder

- » A worker was preparing to cover the cotton with a tarpaulin in a cotton module builder when the control lever became entangled and the plant was accidentally activated: *the prosecution summary stated that following the incident a hinged barrier was fitted along the front of the operator’s position that folds down and diverts all the hydraulic oil flow from the pump through a diverter valve to the storage tank when a person enters the module builder.*

Tractor

- » A worker started a tractor while standing on the ground in front of the rear wheel. The tractor was in gear and lurched forward knocking him down and running over him: *neutral start switches that isolate the ignition circuit if the vehicle is in gear are available and fitted to new tractors. In addition, a safe access platform might have prevented this fatality.*

- Moulding press**
» A worker was electrocuted whilst changing plates on a rubber moulding press: *the prosecution summary stated that to change the plates, the covers of the electrical heating element at the rear of the press had to be removed, exposing live electrical wires.*
- Mixing machine**
» A stock feed mixing machine was inadvertently turned on while a worker was cleaning the inside: *the company responded promptly to the WorkCover investigation of this incident and had guarding and interlocking devices fitted to the machinery.*

Driver obstructed vision

Over the period 2006 to 2011 there were 14 fatal incidents on worksites considered design-related (resulting in 15 work-related fatalities) where workers or a bystander were struck by a vehicle — in nearly all cases while reversing. This study considered that these incidents were related to the driver’s vision being obstructed. In addition to the use of reversing warning alarms, obstructed vision can be ameliorated by installing reversing cameras and proximity detectors: technology that is commonly fitted in modern vehicles and has been commercially available for some time. In one of the incidents the truck involved had a reversing camera that was not functioning — the response to the incident by the company included declaring that vehicles without a functioning reversing camera could not be used on site and keeping a portable unit on site at all times.

Table 6 shows the type of vehicle involved in the incidents, all of which involved workers or bystanders on foot being struck by the vehicle. Measures to prevent incidents such as these should include clear traffic management plans and the use of spotters, since reversing cameras are not fail-safe passive devices and are only effective if the driver uses them assiduously.

Table 6: Design-related work-related fatalities: Driver obstructed vision circumstance category by confidence category, 2006 to 2011 combined

Type of vehicle involved	Confidence category		
	Definite	Possible	Total
Trucks	2	6	8
Rail maintenance train	0	2	2
Grader	0	1	1
Road roller	0	1	1
Front-end loader	0	1	1
Trolley trailer	1	0	1
Fork lift	0	1	1
Total	3	12	15

Brief narratives and comments on the 3 'definite' design-related fatal incidents associated with Driver obstructed vision are presented below:

Reversing truck

- » A worker was struck by a trailer attached to a truck that was being reversed. The worker was behind the truck talking to a driver in another truck. The offending truck driver did not see the deceased when he began reversing: *the WHS investigation found that had the reversing truck driver had use of a rear-vision camera the incident might have been avoided. After the incident the company installed reversing lights and reverse (squawker) alarms on all trailers; reinforced that no trucks were to be reversed in the yard without spotters and that all trucks were to be parked by the detailers; and introduced daily checking of the driver's hours to manage fatigue issues.*

Reversing truck and trailer

- » A bystander sustained serious and ultimately fatal head injuries when struck by a reversing trailer (after returning trolleys) in the loading bay at a shopping centre: *the police report noted that the trailer was not fitted with any reverse beepers or lights and had solid steel ramps that appeared to block the driver's rear vision.*

Reversing garbage truck

- » A driver was reversing his truck towards rubbish bins at a retirement village when a resident ran out behind to put rubbish in the bins. The reversing truck struck the resident: *the Coroner's report stated that at the time of the incident the truck was fitted with two cameras, one on the rear of the truck and one on the arm of the truck. However, the rear camera had a blind spot located close to the rear axle and was not able to pick up movement in a closer proximity than approximately 3 metres from the back of the truck. The camera was replaced and the hazard at that site reduced by moving the bins to the outside of the property so the refuse truck did not have to enter the retirement village.*

Malfunctioning or failed equipment

The Malfunctioning or failed equipment circumstance category was coded to a fatal incident when the malfunction or failure was considered design-related rather than a maintenance issue. Overall there were 12 fatalities (the result of 11 fatal incidents) coded to Malfunctioning or failed equipment (Table 7).

There were few commonalities among the incidents other than the two incidents involving suspended scaffolding. These two incidents resulted in 3 fatalities and might have claimed a fourth life were it not for the surviving worker having a correctly anchored shock absorbing fall restraint harness. The co-worker that died was wearing a harness, but the rope attaching him to the scaffold failed under the shock load as he fell. In this incident only one anchor on the suspended scaffolding failed. In the other incident, both workers were harnessed and anchored to the suspended scaffolding, but the roof anchorage failed completely and the workers fell with the scaffold.

Table 7: Design-related work-related fatalities: Malfunctioning or failed equipment circumstance category by confidence category, 2006 to 2011 combined

Type of equipment involved	Confidence category		Total
	Definite	Possible	
Suspended scaffolding	0	3	3
Wear bend on air hose	0	1	1
Woodworking router	1	0	1
Concrete pump boom	0	1	1
Stock picker forklift truck	1	0	1
Elevating work platform	1	0	1
Truck mounted crane	1	0	1
Pile driver crane	1	0	1
Concrete form work	1	0	1
Hospital patient lifting frame	0	1	1
Total	6	6	12

Brief narratives and comments on the 6 'definite' design-related fatal incidents caused by Malfunctioning or failed equipment are presented below:

Form work

- » A worker was crushed when formwork for flooring collapsed during a concrete pour: *WHS found that the formwork was assessed as not meeting Australian standards and used wooden props rather than metal.*

Elevating work platform

- » A worker fell from an elevating work platform that became unbalanced. The worker was wearing a harness but it was not secured properly. Another worker in the work platform was harnessed correctly and survived: *the EWP became unstable because both an electrical proximity switch was disabled and the hydraulic vertical limit valve had seized. The Coroner's report stated that "the immobilisation of the proximity switch was ... most likely an oversight, possibly by someone involved in maintenance of the machine ... as a result of this incident, the manufacturers of the machine issued a field service bulletin effecting a software upgrade so it is no longer possible when using the analyser to turn off the proximity switch. In addition the poorly designed plunger leading to corrosion has been redesigned".*

Crane boom

- » A worker was struck by a collapsing crane boom: *the Coroner's report states that an investigation found a number of causal factors were together responsible for the crane falling, of which the design of the crane was determined to be most significant. Specifically the crane was inherently sensitive to side loads due to a lack of torsional rigidity in the chassis and the configuration and condition of the rear and front suspension. Micro fatigue cracks were found in welds in the chassis that rendered the crane laterally unstable.*

Routing machine

- » A worker was struck in the chest by a piece of a router tool that shattered during use: *the prosecution summary highlighted that the machine rotated the tool at approximately twice its safe operational speed and that the tool was of inappropriate size and shape and was unbalanced.*

Forklift workbox

- » A worker fell 4 metres from a forklift workbox that then also fell on him: *although there is little further detail about the incident, the workbox was not a registered design and was not secured to the tines of the fork lift when it was lifted.*

Pile driver crane

- » A worker was struck by part of a crane piledriver when a concrete pile being hoisted fell: *the Coroner concluded that the collapse of the pile driving tower was caused by the failure of a retaining pin in the swivel connector that then allowed the piling tower to detach from the boom head and collapse. The failure of the retaining pin was due to poor design and manufacture.*

Unapproved modification

Table 8 shows that there were 11 work-related fatalities considered design-related (the result of 10 fatal incidents) that were coded to Unapproved modification. In 6 incidents unapproved modifications disabled existing safety features while in the remaining 4 incidents the modifications or repairs were of poor design and introduced a new hazard that caused the death of a worker, or in one incident, 2 workers.

These incidents could have been included under the relevant circumstance category, such as Inadequate guarding or Lack of interlock, but these examples help highlight the importance of maintenance checks to ensure that existing safety features function as designed.

Table 8: Design-related work-related fatalities: Unapproved modification circumstance category by confidence category, 2006 to 2011 combined

Type of vehicle or equipment involved	Confidence category		
	Definite	Possible	Total
Road tanker	0	2	2
Timber mill circular saw	1	0	1
Tractor driven bird net roller (modified to roll reflective matting)	1	0	1
Hydraulic vehicle hoist	0	1	1
Loading ramp	0	1	1
Cement truck	1	0	1
Egg washing machine	1	0	1
Bell Logger (log moving vehicle)	1	0	1
Sand blasting hose	1	0	1
Angle grinder	0	1	1
Total	6	5	11

Brief narratives and comments on the 6 'definite' design-related fatal incidents caused by Unapproved modifications are presented below:

Rip saw

- » A worker was hit in the chest by a piece of timber that was kicked back from a rip saw blade: *the prosecution summary stated that the internal anti-kickback fingers had been removed, the rollers and sleeves were damaged, and employees were not precluded from standing in line with the in-feed of the machine.*

Bird netting reel

- » A worker was using a machine for winding up bird netting that had been modified to roll up reflective foil: *the modification left a protruding bolt that caught the workers clothing. The WorkSafe authority recommended simply replacing the bolt with a collar and recessed grub screw to eliminate the hazard.*

Cement truck

- » A worker put his head inside the agitator of his cement truck to view an area that he could not reach from the top of the ladder: *the prosecution summary states that a guard that would have prevented the worker from placing himself in danger had been removed.*

- Egg washing machine**
» A fatal incident occurred because a switchboard residual current device protecting an egg washing and grading machine with an electrical fault was deliberately bypassed pending repairs that were then not carried out: *the Coroner’s report stated that the primary fault was in the manufacture and testing of the machine. However, the fault could not have caused the fatality unless the switchboard protection had been bypassed pending the repairs that were then postponed.*
- Bell logger**
» A worker died when he pressed the ignition button while outside the Bell logger vehicle that then started and ran over him: *the prosecution summary stated that the neutral start safety switch had been bypassed, which allowed the machine to be started while still in gear.*
- Sand blasting hose**
» A worker lost control of a sand blasting hose while inside the hull of a ship: *the WHS investigation found that the main cause of the fatality was a practice that had developed amongst workers to tape down the hand operated lever/switch that activates the charging of the high pressure line. This effectively disabled the fail-safe cut-off should a worker lose their grip of the hose.*

Inadequate fall protection

Working at height is a well-recognised hazard and falls from height have caused the death or injury of many workers (SWA, 2013). The hierarchy of controls prioritises the elimination of hazards where possible. However, for many of the more common tasks requiring work at height, this is probably rarely possible because it would require the task and the materials involved to be brought to ground level. Nevertheless, a good example of eliminating the need to work at height can be found in motorway lighting poles where the lighting units can be lowered to the ground for bulb replacement.

Tasks that must be undertaken at height regularly should be made safer by installing fixed steps and gantries protected by handrails. Similarly, extended tasks such as building construction should use temporary fixed scaffolding to protect workers from falls. However, for occasional access to work at height portable ladders are generally used, and although the worker can use PPE to protect themselves from falls once at height (e.g. once on a roof), they are particularly vulnerable while going up or down a ladder. Similarly working from trestles and planks is hazardous and guard rails should be used above 2 metres and if possible even at lower heights (SWA, 2011b).

Table 9 shows that there were 10 work-related fatalities considered design-related that were coded to Inadequate fall protection. The most common types of equipment involved were trestles and ladders.

Table 9: Design-related work-related fatalities: Inadequate fall protection circumstance category by confidence category, 2006 to 2011 combined

Type of equipment involved	Confidence category		
	Definite	Possible	Total
Trestles	2	1	3
Ladders	0	2	2
Aircraft loading platform hoist	1	0	1
Forklift work box	0	1	1
Tower crane	1	0	1
Overhead walkway	1	0	1
Mining truck	0	1	1
Total	5	5	10

Brief narratives and comments on the 5 'definite' design-related fatal incidents associated with Inadequate fall protection are presented below:

Trestle platforms

- » A self-employed painter fell 4 metres from a trestle that was not appropriate or secured: *the Coroner's report highlighted that the painter was working on an extendable ladder on 4 metre high trestles. The trestles were double planked, not clamped, not weighted, not fastened to the structure and positioned on slightly sloping ground.*
- » A worker was standing on top of a plank, supported by trestles, that was about 5 metres above the ground. The worker lost his balance and fell backwards: *the Coroner's report noted that the scaffolding was poorly conceived, poorly constructed and of an inadequate structural integrity and form. There were also no hand rails or horizontal restraints of any sort.*

Aircraft catering platform hoist

- » A worker fell 5 metres from an aircraft catering platform onto the tarmac: *the Coroner's report noted that, although the height and configuration of the guard rail was within the applicable Australian standards, an international standard indicated the top rail should have been higher at a level of 1.1 meters from the base. It was also noted that the edge of the platform did not have a kick plate or toe board. The company have since raised the height of the guard rails on all catering and cabin cleaning vehicles and an enclosed system for the platform extension has also been incorporated in the new design.*

Tower crane

- » A worker performing maintenance work on the boom of a tower crane fell: *the Coroner's report highlighted the absence of a static line to which he might have attached his safety harness.*

Overhead walkway

- » A worker fell 30 metres from an overhead walkway near a conveyor belt system feeding storage bins: *the prosecution summary stated that the grid mesh panels on the walkway were largely unsecured and no alternative fall arrest system was provided to workers using the walkway. Following the incident purpose designed clips were used to secure the grid mesh panels to the walkway.*

Poor control layout

The design and layout of controls for machinery and mobile plant is an important aspect of industrial design. The controls are the main interface between the worker and the machine and where they are located and how they work should be considered when assessing possible safety hazards.

Table 10 shows that there were 9 fatal incidents that were considered design-related and were coded to Poor control layout.

Tractor three-point linkage

Two of the incidents involving tractors happened under similar circumstances when the worker activated the hydraulic three-point linkage controls while standing behind the tractor — the controls should only be operated from the driver's seat, but in these incidents the controls could also be reached from the back of the tractor.

Table 10: Design-related work-related fatalities: Poor control layout circumstance category by confidence category, 2006 to 2011 combined

Type of equipment involved	Confidence category		Total
	Definite	Possible	
Tractors	0	3	3
Buses	2	0	2
People mover	0	2	2
Mobile crane	0	1	1
Road rollers	0	1	1
Total	2	7	9

The two incidents involving Buses also occurred under very similar circumstances and are summarised in the narrative below.

Bus doors

- » Two fatal incidents occurred (at different times) when drivers became trapped in the closing door of their bus. In both cases the drivers had used the emergency door button on the stairwell just inside the bus to close the door from the outside: *the Coroner's reports for the two incidents both stated that the company modified the door mechanisms to reduce the speed and force at which they closed, and one of the companies also moved the emergency switch so it could not be reached from outside the door.*

Runaway vehicle / park brake

Table 11 shows that there were 8 work-related fatalities considered design-related that were coded to Runaway vehicle / park brake. In nearly all cases the fatal incident was the result of the driver failing to properly apply the park brake of their vehicle.

The Australian Trucking Association recommend that trucking operators consider fitting driver door interlocks that sound an alarm if the door is opened when the transmission is in neutral and the park brake is not applied (ATA, 2013). This simple technology could help prevent numerous incidents of runaway vehicles.

Table 11: Design-related work-related fatalities: Runaway vehicle / park brake circumstance category by confidence category, 2006 to 2011 combined

Type of equipment involved	Confidence category		Total
	Definite	Possible	
Trucks	0	7	7
Bulldozer	0	1	1
Total	0	8	8

Brief narratives on three of the fatal incidents are presented below:

Bulldozer

- » A bulldozer driver attempted to re-board his moving vehicle after having forgotten to apply the park brake. As he tried to climb back onto the bulldozer, he fell between the track and the body of the vehicle.

Truck

- » A worker was crushed while walking between a small truck and a larger truck that rolled forwards. The worker had just jump started the smaller truck from the larger truck. The larger truck was found to be in neutral with the hand brake off.

Truck and trailers

- » A driver was hooking up his prime mover to two trailers. When he connected the red air supply hose the pressure released the trailer's spring brakes and the prime mover and trailer started to roll away. The driver was run over by the prime mover, presumably while trying to re-enter the cabin.

Lack of high tension detection

Overhead power lines are a common and usually readily visible hazard on farms, construction sites and roadside locations — and yet too easily missed or forgotten for that very reason. The primary protection should be fencing and clear hazard signage. In some circumstances, such as road works and construction sites very close to overhead lines, the wires can be temporarily flagged and insulated by the electricity authority.

In addition to these physical methods of protection, electronic power line warning units can be installed in tipping trucks and other elevating mobile plant to warn an operator that the tray is coming too near to a high voltage line.

This study identified 2 fatal incidents that were coded to Lack of high tension detection, both involving tipping trucks that contacted overhead power lines. However, there have been other fatal incidents involving agricultural workers moving agricultural machinery, such as irrigation pipes, that did not fall under the scope of this study.

Brief narratives of the 2 fatal incidents are listed below.

Tipping trucks

- » A worker standing near to a 36 ft tipping trailer was electrocuted when the elevated tray struck an overhead power line.
- » A farm worker touched a tipping truck that had moved forward while unloading and contacted overhead power lines.

Lack of smoke / fire detection

The fact that only one fatal incident over the study period was coded to the circumstance category Lack of smoke / fire detection perhaps reflects that, over that period, inexpensive smoke detector technology has been readily available.

The one fatal incident listed below might have been prevented had the truck sleeping compartment been fitted with a smoke detector.

Truck cabin

- » A 12 volt portable electric kettle boiled dry and started a fire inside the cab of a truck in which the driver was sleeping.

Other circumstances

Table 12 shows there were 15 fatal incidents that did not fall into the specific circumstance categories already described and involved a variety of equipment and vehicles. There were no notable commonalities among the incidents. However, there was another fatality similar to the one involving a high pressure water blasting lance that had no trigger device included in this Other circumstances category. The similar fatality was coded to Unapproved modifications because although the high pressure sand blasting nozzle did have a trigger that would shut off supply if the worker lost grip on the hose, it was ineffective because the trigger had been taped open.

Table 12: Design-related work-related fatalities: Other circumstance category by confidence category, 2006 to 2011 combined

Type of vehicle or equipment involved	Confidence category		Total
	Definite	Possible	
Gas cylinders	1	1	2
Trucks (Cement truck / fire truck)	0	2	2
Loading ramps	2	0	2
Step ladders	0	1	1
Front-end loader	0	1	1
Impact cannon	0	1	1
Drilling rig	1	0	1
Work cage	0	1	1
Hopper tank	0	1	1
Low loader	0	1	1
Wire "cockies" gate	0	1	1
High pressure water blaster	1	0	1
Total	5	10	15

Brief narratives and comments on the 5 'definite' fatal incidents in which unsafe design played a part are presented below:

Hydraulic loading ramp

- » A worker activated a hydraulic loading ramp on a heavy machinery float trailer but was struck by the ramp when he moved into its path: *the Workcover authority investigation noted that these ramps operated without the necessity for the controller to stay at the controls.*

Loading ramp

- » A worker unloading a forklift truck from a trailer was killed when one of the ramps fell and the forklift toppled over: *the Coroner's report noted the lack of pins or any similar mechanism to hold the ramps in place.*

Drilling rig counterweight

- » A worker was struck by a counterweight that fell from a drilling rig while being removed: *the Coroner's report stated that in compliance with a prohibition notice the company conducted a number of steps to manage the risk including designing, testing and implementing a new interlocking counterweight securing safety device. They also amended the safe work method statement and re-trained employees.*

Gas cylinders

- » A worker was killed when his vehicle exploded. The vehicle had gas cylinders stored inside: *the Coroner's report stated that the company removed all gas cylinders from its remaining enclosed vehicles; implemented a work place instruction banning staff from transporting all gas cylinders in enclosed vehicles; and commenced a workplace practice where gas cylinders were delivered to and retrieved from worksites as required in an open vehicle. The company also installed sealed vented gas cabinets in each of its work vans.*

**High pressure
water lance**

- » A worker died when he was struck by the high pressure cleaning lance he was using: *the Coroner's report highlighted that contrary to an Australian Standard concerning high pressure water jetting and the company's own operating procedures, the worker had no direct control over the water flow by way of a trigger device and there were no handles on the lance.*

Industry of employer

Table 13 shows the industry of employer for the 183 workers (5 were bystanders) who died in a design-related fatal incident. The industries of employer of the deceased workers are predictably skewed towards those that commonly use the types of machinery, plant, and powered tools that come under the scope of the study.

Table 13: Design-related work-related fatalities: industry of employer by most common^(a) circumstance category by confidence category, 2006 to 2011 combined

Industry of employer / Circumstance category	Confidence category		Total
	Definite	Possible	
Agriculture, forestry & fishing	19	33	52
<i>Lack of roll-over protection structures / seat belts</i>	8	17	25
<i>Inadequate guarding</i>	5	8	13
<i>Lack of interlock</i>	2	2	4
Construction	11	40	51
<i>Lack of residual current device</i>	0	12	12
<i>Inadequate guarding</i>	1	7	8
<i>Driver obstructed vision</i>	1	6	7
Manufacturing	19	16	35
<i>Inadequate guarding</i>	6	6	12
<i>Lack of interlock</i>	2	5	7
<i>Malfunctioning / failed equipment</i>	4	1	5
Transport, postal & warehousing	3	18	21
<i>Runaway vehicle / park brake</i>	0	6	6
<i>Driver obstructed vision</i>	0	4	4
<i>Unapproved modification</i>	0	3	3
Mining	1	6	7
<i>Other circumstance</i>	1	3	4
<i>Inadequate fall protection</i>	0	1	1
<i>Malfunctioning / failed equipment</i>	0	1	1
Administrative & support services	1	4	5
<i>Lack of residual current device</i>	1	1	2
<i>Inadequate guarding</i>	0	2	2
<i>Driver obstructed vision</i>	0	1	1
Accommodation & food services	2	1	3
Retail trade	1	1	2
Public administration & safety	0	1	1
Rental, hiring & real estate services	1	0	1
Education & training	1	0	1
Electricity, gas, water & waste services	0	1	1
Professional, scientific & technical services	0	1	1
Other services	1	0	1
Industry unknown	1	0	1
Bystander	2	3	5
Total	63	125	188

(a) Only the three most common circumstance categories are shown for each industry with 5 or more design-related fatal incidents.

Just over half (55%) of the workers who died in a design-related incident were employed in the Agriculture, forestry & fishing (28%) or the Construction industries (27%). A further 19% were employed in the Manufacturing sector, 11% in the Transport, postal & warehousing industry, and 4% in the Mining industry.

Agriculture, forestry & fishing

The most common design-related circumstance category in the Agriculture, forestry & fishing industry, with 25 fatalities, was Lack of roll-over protection structures / seat belts — most of these involved tractors or quad bikes. Inadequate guarding was also a common circumstance with 13 fatalities.

Construction

In the Construction industry the most common design-related circumstance category was Lack of residual current device; there were 12 fatalities, most involving electricians. Of the 8 fatalities coded to Inadequate protection, 5 were elevating work platform crushings. There were 7 fatalities coded to Driver obstructed vision.

Manufacturing

The most common design-related circumstance categories in the Manufacturing industry were machinery related: 12 fatalities were coded to Inadequate guarding, 7 to Lack of interlock, and 5 to Malfunctioning / failed equipment.

Transport, postal & warehousing

In the Transport, postal & warehousing industry the most common single circumstance category, with 6 fatalities, was Runaway vehicle / park brake. This was closely followed by 5 incidents coded to Driver obstructed vision.

Safe work systems

Although this report is primarily focused on the design-related aspects of fatal incidents involving specific categories of machinery, plant and tools, in nearly all these incidents the fatality might have been avoided if the workplace had better work systems that were closely adhered to.

A safe system of work requires clearly documented procedures that are based on a systematic examination of the tasks involved and the potential hazards identified. A full explanation of this process can be found in the code of practice for managing the risks of plant in the workplace (SWA, 2012).

Many of the brief comments made on the fatal incidents listed in this report make mention of work system issues. Overall the most common work system failures included poor traffic management, poor hazard identification, the lack of clearly documented safe procedures, inadequate training, and failure to wear effective PPE.

The three incidents below highlight many of these work system issues:

- » A worker was struck by a trailer attached to a truck that was being reversed. The worker had been behind the truck talking to a driver in another truck. The offending truck driver did not see the deceased when he began reversing: *the Coroner's report stated that after the incident the company installed reversing lights and reverse (squawker) alarms on all trailers; reinforced that no trucks were to be reversed in the yard without spotters and that all trucks were to be parked by the detailers; and introduced daily checking of the driver's hours to manage fatigue issues.*
- » A worker was crushed in the cabin of an excavator that tipped over while being unloaded off a low loader: *the prosecution summary stated that the tracks of the excavator exceeded the width of the tray by 30cm, and the trailer also had a steel tray and the excavator had steel tracks. The Load Restraint Guide recommends that tracks "should not" hang over by more than 15cm, and that the effect of steel-on-steel reduces traction, causing an appreciable risk of slipping occurring. The company involved had previously experienced a very similar incident and at that time there had been no risk or hazard assessment done, and there had been no training or instructional material provided. Prohibition Notices issued at the time were withdrawn when the company undertook to improve their system of work and introduce rubber matting and spread-deck trailers. However, none of these improvements were implemented.*
- » A worker died when an industrial blender he was cleaning started unexpectedly: *the prosecution summary stated that the company had not provided systematic and consistent training to employees in relation to the procedures to be followed when cleaning the blender, for example, in relation to isolation, tagging and lockout procedures. The training that had been provided consisted of on-the-job training by co-workers who had themselves been trained by other co-workers. This had the result that the employees gained different understandings of the procedures involved.*

Conclusions

Although there is some uncertainty in the precise number of fatalities attributable to unsafe design, due to limited information and the subjective nature of the assessment, around 36% of in scope workplace deaths over the period 2006 to 2011 were definitely or possibly attributable to unsafe design of machinery, plant and powered tools.

At the broadest level the same conclusions can be drawn from this study as were drawn in an earlier study in 2005 (ASCC, 2005).

- » unsafe design is a significant contributor to fatal incidents in many industries
- » there are many commonalities in the circumstances of the fatal incidents, and
- » there are existing solutions for most of the common identified design-related problems.

The most prominent design-related circumstance was inadequate guarding of machinery: though these incidents involved many different types of machinery that require quite different guarding mechanisms. Tractor and quad bike roll-overs are both well-known issues that have received considerable attention and the potential of residual current devices to protect against electrocutions is reflected in their mandatory use in many situations. The principle of ensuring that access to hazardous machinery for maintenance etc. is restricted by fail-safe interlock systems is also well-known. The problem of restricted vision while reversing mobile plant and other vehicles is also well recognised and reversing cameras have been available for many years — and are relatively easy to retrofit on a commercial vehicle.

Less well-known is the number of fatal incidents involving the users of elevating work platforms being crushed against roofing and beams (7 over the 2006 to 2011 period). Some manufacturers are responding to this risk with caged platforms with anti-entrapment devices such as a frame fitted to the basket that provides a “safe zone” within the platform and sensor bars or pads that stop the movement of the basket should the operator be pushed onto them.

The types of fatal incident identified in this study were broadly similar to those identified in the earlier study (SWA, 2005), though the ranking has changed slightly. The lack of rollover protection was the most common category in the 2000-01 to 2001-02 study, followed by guarding issues and the lack of residual current devices. However, the earlier study did not identify any crushing incidents involving elevating work platforms. Although the 2000-01 to 2001-02 study did not restrict the fatal incidents examined on the basis of breakdown agency, very few design-related incidents were identified outside the scope used in this study.

A number of the incidents highlighted in this report involved old machinery and plant, some of which may remain in use for many years. This is a recognised issue and has been the subject of an intervention campaign carried out among selected manufacturing groups by Australian WHS jurisdictions under the administration of the Heads of Workplace Safety Authorities. Safety inspectors audited over 1070 individual machines from a total of around 4500 fixed powered machines. Of the machinery inspected, Inspectors identified 334 (31%) machines with potential hazards that were not adequately controlled by the workplace (HWSA, 2009).

Fatal incidents were made the basis of this study because the information sources are generally adequate to judge the involvement of design issues. However, the types of incidents highlighted in this study are likely to cause far more injuries than they do deaths. Unfortunately, because of the paucity of information available on non-fatal incidents, particularly from worker's compensation data, it was not practical to include them in this study. The narratives available with workers' compensation claims (the main source of information on workplace injuries) are generally inadequate to make a judgement on the involvement of design-related issues. Safe Work Australia is currently considering making greater use of the information published on prosecutions related to work-related injuries and deaths.

Nonetheless, this report, and earlier studies, highlight the need for greater vigilance by work site managers to identify and protect against workplace hazards that result from poor design. And, as illustrated by the incident highlighted on the opening page of this report, the cost of implementing guarding or interlock modifications can be quite modest compared to the devastating impact of a worker suffering serious injury or death.

Designers and manufacturers of new machinery and plant must fulfil their duty of care for the safety of users of their products by including the type of passive protection so clearly seen as lacking in many of the incidents described in this report (SWA, 2012b).

References

- Australian Safety and Compensation Council (ASCC), *Guidance on the principles of safe design for work*, Canberra, 2006.
- Australian Trucking Association (ATA), *Don't park your trailers on air*, Media release, Canberra, 22 November 2013.
- Heads of Workplace Safety Authorities (HWSA), *Guarding of machinery in manufacturing: final report*, 2009.
- Health and Safety Executive (HSE), *Mobile elevated work platform (MEWP) incident analysis*, Research Report 961, UK, 2013.
- National Occupation Health & Safety Commission (NOHSC), *Work-related fatalities associated with design issues involving machinery and fixed plant in Australia, 1989 to 1992*, Canberra, September, 2000.
- National Occupation Health & Safety Commission, *The role of design issues in work-related injuries in Australia 1997-2002*, Canberra, July 2004.
- Office of the Australian Safety and Compensation Council (ASCC), *Design issues in work-related serious injuries*, Department of Employment and Workplace relations, Canberra, 2005.
- Safe Work Australia (SWA), *Fatalities due to working with tractors, Australia 2003–04 to 2006–07*, May 2011a.
- Safe Work Australia, *Managing the risk of falls at workplaces: Code of practice*, December 2011b.
- Safe Work Australia, *Managing electrical risks in the workplace: Code of practice*, July 2012a.
- Safe Work Australia, *Managing the risks of plant in the workplace: Code of practice*, July 2012b.
- Safe Work Australia, *Work-related injuries and fatalities involving a fall from height, Australia*, October 2013.

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