



Australian Government

Australian Transport Safety Bureau



ATSB TRANSPORT SAFETY REPORT

Marine Occurrence Investigation No. 273

MO-2010-002

Final

Independent investigation into the stevedore fatality on board the
Antigua and Barbuda registered container ship

Vega Gotland

at Port Botany, New South Wales

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Figure 1 is provided courtesy of Clyde Dickens (Shipspotting.com). Figure 5 was obtained from Patrick Terminals' training documentation. Figure 9 was obtained from the Australian Maritime Safety Authority.

Abstract

At about 1918 on 28 March 2010, a stevedore was crushed between two containers during loading operations on board the container ship *Vega Gotland*, while it was berthed at the Patrick Terminals' Port Botany terminal. The stevedore, who was the lashing team leader, died instantly from the injuries he received in the accident.

The ATSB investigation found that the lashing team leader had placed himself in a position of danger and that when a twistlock foundation unexpectedly failed during the repositioning of the container, he was unable to get clear of the swinging container.

The investigation also found that the failure of the twistlock foundation was brought about by an attempt to reposition the container and was consistent with its exposure to gross overstress conditions as a result of the leverage forces applied to it by the container and the unsecured hatch cover.

The investigation identified that while the dangers of working between a moving container and a fixed object were taught to Patrick Terminals' new employees during their induction training, the issue was not specifically covered or reinforced in the company's safe work instructions, the hazard identification and associated risk control processes nor, in some instances, followed in practice by stevedores on board the ships in the terminal.

The ATSB identified seven safety issues during the investigation. The safety issues related to: the absence of policies or procedures concerning safety zones near container operations; that Patrick Terminals' safety management system contained deficiencies; the discontinuity between what was taught to new employees and the contents of the safe work instructions and hence the practices on the work site; hazard identification and associated risk controls for lashing and unlashings; review and compliance auditing of safe work instructions and reporting risk-related events; and that the recognised safe practices of not working under or near a container being loaded were not well reflected in national and international guidance.

The ATSB acknowledges the safety action taken by Patrick Terminals and is satisfied that it adequately addresses the safety issues. The ATSB has issued one safety advisory notice concerning national and international guidance not reflecting the recognised safe practices of not working under or near a container being loaded onto a ship.

THE AUSTRALIAN TRANSPORT SAFETY BUREAU

The Australian Transport Safety Bureau (ATSB) is an independent Commonwealth Government statutory agency. The Bureau is governed by a Commission and is entirely separate from transport regulators, policy makers and service providers. The ATSB's function is to improve safety and public confidence in the aviation, marine and rail modes of transport through excellence in: independent investigation of transport accidents and other safety occurrences; safety data recording, analysis and research; fostering safety awareness, knowledge and action.

The ATSB is responsible for investigating accidents and other transport safety matters involving civil aviation, marine and rail operations in Australia that fall within Commonwealth jurisdiction, as well as participating in overseas investigations involving Australian registered aircraft and ships. A primary concern is the safety of commercial transport, with particular regard to fare-paying passenger operations.

The ATSB performs its functions in accordance with the provisions of the Transport Safety Investigation Act 2003 and Regulations and, where applicable, relevant international agreements.

Purpose of safety investigations

The object of a safety investigation is to identify and reduce safety-related risk. ATSB investigations determine and communicate the safety factors related to the transport safety matter being investigated. The terms the ATSB uses to refer to key safety and risk concepts are set out in the next section: Terminology Used in this Report.

It is not a function of the ATSB to apportion blame or determine liability. At the same time, an investigation report must include factual material of sufficient weight to support the analysis and findings. At all times the ATSB endeavours to balance the use of material that could imply adverse comment with the need to properly explain what happened, and why, in a fair and unbiased manner.

Developing safety action

Central to the ATSB's investigation of transport safety matters is the early identification of safety issues in the transport environment. The ATSB prefers to encourage the relevant organisation(s) to initiate proactive safety action that addresses safety issues. Nevertheless, the ATSB may use its power to make a formal safety recommendation either during or at the end of an investigation, depending on the level of risk associated with a safety issue and the extent of corrective action undertaken by the relevant organisation.

When safety recommendations are issued, they focus on clearly describing the safety issue of concern, rather than providing instructions or opinions on a preferred method of corrective action. As with equivalent overseas organisations, the ATSB has no power to enforce the implementation of its recommendations. It is a matter for the body to which an ATSB recommendation is directed to assess the costs and benefits of any particular means of addressing a safety issue.

When the ATSB issues a safety recommendation to a person, organisation or agency, they must provide a written response within 90 days. That response must indicate whether they accept the recommendation, any reasons for not accepting part or all of the recommendation, and details of any proposed safety action to give effect to the recommendation.

The ATSB can also issue safety advisory notices suggesting that an organisation or an industry sector consider a safety issue and take action where it believes it appropriate. There is no requirement for a formal response to an advisory notice, although the ATSB will publish any response it receives.

TERMINOLOGY USED IN THIS REPORT

Occurrence: accident or incident.

Safety factor: an event or condition that increases safety risk. In other words, it is something that, if it occurred in the future, would increase the likelihood of an occurrence, and/or the severity of the adverse consequences associated with an occurrence. Safety factors include the occurrence events (e.g. engine failure, signal passed at danger, grounding), individual actions (e.g. errors and violations), local conditions, current risk controls and organisational influences.

Contributing safety factor: a safety factor that, had it not occurred or existed at the time of an occurrence, then either: (a) the occurrence would probably not have occurred; or (b) the adverse consequences associated with the occurrence would probably not have occurred or have been as serious, or (c) another contributing safety factor would probably not have occurred or existed.

Other safety factor: a safety factor identified during an occurrence investigation which did not meet the definition of contributing safety factor but was still considered to be important to communicate in an investigation report in the interests of improved transport safety.

Other key finding: any finding, other than that associated with safety factors, considered important to include in an investigation report. Such findings may resolve ambiguity or controversy, describe possible scenarios or safety factors when firm safety factor findings were not able to be made, or note events or conditions which ‘saved the day’ or played an important role in reducing the risk associated with an occurrence.

Safety issue: a safety factor that (a) can reasonably be regarded as having the potential to adversely affect the safety of future operations, and (b) is a characteristic of an organisation or a system, rather than a characteristic of a specific individual, or characteristic of an operational environment at a specific point in time.

Risk level: The ATSB’s assessment of the risk level associated with a safety issue is noted in the Findings section of the investigation report. It reflects the risk level as it existed at the time of the occurrence. That risk level may subsequently have been reduced as a result of safety actions taken by individuals or organisations during the course of an investigation.

Safety issues are broadly classified in terms of their level of risk as follows:

- **Critical** safety issue: associated with an intolerable level of risk and generally leading to the immediate issue of a safety recommendation unless corrective safety action has already been taken.
- **Significant** safety issue: associated with a risk level regarded as acceptable only if it is kept as low as reasonably practicable. The ATSB may issue a safety recommendation or a safety advisory notice if it assesses that further safety action may be practicable.
- **Minor** safety issue: associated with a broadly acceptable level of risk, although the ATSB may sometimes issue a safety advisory notice.

Safety action: the steps taken or proposed to be taken by a person, organisation or agency in response to a safety issue.

EXECUTIVE SUMMARY

On 28 March 2010, the Antigua and Barbuda registered container ship *Vega Gotland* was berthed at the Patrick Terminal in Port Botany, New South Wales. During the late afternoon and early evening, the ship was loading containers, using shore portainer cranes (portainers) and stevedoring labour.

At 1742¹, the stevedores left *Vega Gotland* to have their evening meal break. After about an hour, they returned to the ship and resumed loading containers on deck. The stevedores included a team of eight lashers (men whose task it was to lash the deck containers after loading).

While the lashers were lashing the containers in Bay 24², four men each at the forward and after end of the bay, the deck team leader asked those at the forward end to move out of the way as containers were about to be loaded on deck in the adjacent Bay 20. The four lashers, including the lashing team leader, complied and moved to the safety of the outboard, port side hatch cover of Bay 24, where there were no containers.

After the first container, a 40 foot refrigerated container, was landed in Bay 20, the deck team leader locked the manual twistlocks³ and the lashers began putting lashing rods and turnbuckles on the container. After the second container had been landed, on deck inboard of the first one, in an attempt to save some time, the deck team leader asked the lashing team leader if he could lock the after twistlocks on the remaining containers which were to be loaded in that bay. The lashing team leader agreed.

Like the two containers loaded before it, the third container did not land squarely on the four corner twistlocks. To assist the portainer driver with the task of aligning the container over the after twistlocks, the deck team leader locked the forward inboard twistlock. The portainer driver then lifted the container slightly so that he could manoeuvre it into position. However, as he did so, the deck team leader felt the hatch cover lift and he immediately told the portainer driver to stop lifting.

However, while he was doing so, the top of the twistlock foundation⁴ separated from its base and the container swung aft. The lashing team leader was standing at the after end of the container. Before he had the chance to move clear, he was crushed between the swinging container and a loaded container on deck in Bay 24. He was killed instantly.

The ATSB investigation found that the lashing team leader had placed himself in a position of danger and that when a twistlock foundation unexpectedly failed during

¹ All times referred to in this report are ship's time, Coordinated Universal Time (UTC) +11.

² See Figure 2. Internationally accepted naming convention referring to the stowage position on ships in which containers are carried. They are numbered from the first forward hold/hatch.

³ A device used to secure the corners of stacked containers together or to secure a container to the ship. They consist of a hot dipped galvanised cast steel body which contains a movable central shaft. The shaft has a cone at the top and, depending on the type of twistlock, another at the bottom.

⁴ An elevated 'stool' on the hatch cover in which the twistlock sat.

the repositioning of the container, he was unable to get clear of the swinging container.

The investigation also found that the failure of the twistlock foundation was brought about by an attempt to reposition the container and was consistent with its exposure to gross overstress conditions as a result of the leverage forces applied to it by the container and the unsecured hatch cover.

The investigation identified that while the dangers of working between a moving container and a fixed object were taught to Patrick Terminals' new employees during their induction training, the issue was not specifically covered or reinforced in the company's safe work instructions, the hazard identification and associated risk control processes nor, in some instances, followed in practice by stevedores on board the ships in the terminal.

The ATSB identified seven safety issues during the investigation. The safety issues related to: the absence of policies or procedures concerning safety zones near container operations; that Patrick Terminals' safety management system contained deficiencies; the discontinuity between what was taught to new employees and the contents of the safe work instructions and hence the practices on the work site; hazard identification and associated risk controls for lashing and unlashings; review and compliance auditing of safe work instructions and reporting risk-related events; and that the recognised safe practices of not working under or near a container being loaded were not well reflected in national and international guidance.

The ATSB acknowledges the safety action taken by Patrick Terminals and is satisfied that it adequately addresses the safety issues. The ATSB has issued one safety advisory notice concerning national and international guidance not reflecting the recognised safe practices of not working under or near a container being loaded onto a ship.

1.1 *Vega Gotland*

Vega Gotland is a cellular container ship which was built in 2005 by Kouan Shipbuilding Industry, China (Figure 1). It has an overall length of 147.74 m, a breadth of 23.43 m and a deadweight of 13,996 tonnes at its summer draught of 8.50 m.

Figure 1: *Vega Gotland*



Propulsive power is provided by a MAN B&W 7L58/64 four-stroke, single acting diesel engine that delivers 9,730 kW at 428 rpm. The main engine drives a single, controllable pitch propeller through a reduction gearbox, giving the ship a service speed of about 19 knots⁵.

Vega Gotland has a cargo carrying capacity of 1,118 TEU⁶, 220 of which can be refrigerated. The ship can also carry FEUs⁷ over two TEU spaces. It has five cargo holds located forward of the accommodation superstructure. The holds are serviced by two 45 tonne⁸ cranes.

The ship is fitted with MacGregor pontoon type hatch covers, each spilt into a port and a starboard hatch cover. The hatch covers are designed to be lifted on and off the ship using the same portainer crane (portainer) that handles the containers. The hatch covers are secured to the hatch coamings by semi-automatic twistlocks⁹.

⁵ One knot, or one nautical mile per hour equals 1.852 km/hr.

⁶ Twenty-foot Equivalent Unit, a standard shipping container of 20 foot in length. The nominal size of a ship in TEU refers to the number of standard containers that it can carry.

⁷ Forty-foot Equivalent Unit, a standard shipping container of 40 foot in length.

⁸ Safe working load.

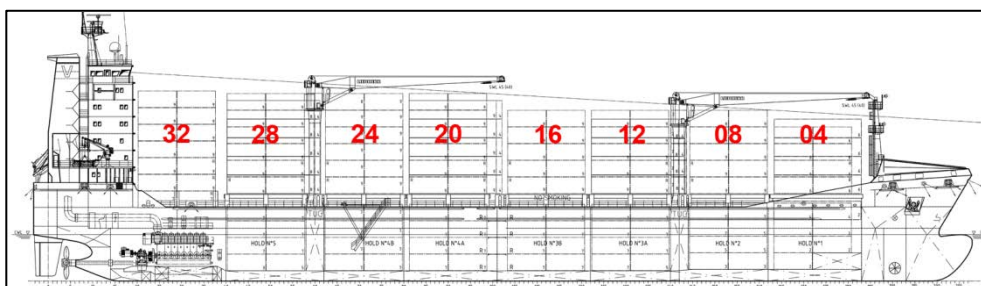
⁹ A device used to secure the corners of stacked containers together or to secure a container to the ship. They consist of a hot dipped galvanised cast steel body which contains a movable central shaft. The shaft has a cone at the top and, depending on the type of twistlock, another at the bottom.

At the time of the accident, *Vega Gotland* was owned by MS Vega Gotland Schiffahrtsgesellschaft and managed by Vega Reederei Friedrich Dauber, both of Germany. It was registered in Antigua and Barbuda and classed with Bureau Veritas (BV).

1.1.1 Numbering convention of hatches

Like other cellular container ships, the designation of holds and their associated hatch covers on board *Vega Gotland* follows a standard numbering convention. Each athwartships row of 20 foot container spaces (slots) is referred to as a 'Bay', and are odd numbered from forward to aft, i.e. Bay 1, Bay 3, Bay 5 etc. When a FEU is carried in two TEU container slots, the numbering convention remains the same except that the numbering becomes even. So for a FEU carried over Bays 11 and 13, the numbering convention is to call that Bay 12, and similarly for a FEU carried over Bays 19 and 21, that bay is referred to as Bay 20 (Figure 2).

Figure 2: Forty foot container bay numbering on board *Vega Gotland*



1.1.2 Container stowage on board *Vega Gotland*

Containers can be stowed on *Vega Gotland*'s hatch covers to a maximum of six high. The maximum stacking weight for FEUs on the hatch covers is 80 tonnes.

The containers are 'locked' together, and to the ship's hatch covers, by twistlocks. Twistlocks are made of a hot-dipped galvanised cast steel body which contains a movable central shaft. The shaft has a cone at the top and, depending on the type of twistlock, another at the bottom.

When in the 'unlocked' position, the cone/s align with the container corner casting hole or deck fittings. For 'manual' twistlocks, when in place between containers or the ship, the containers are 'locked' together by moving the twistlock shaft (and cone/s) using a handle attached to the shaft, through about 80° so that the cone/s are no longer aligned with the casting hole.

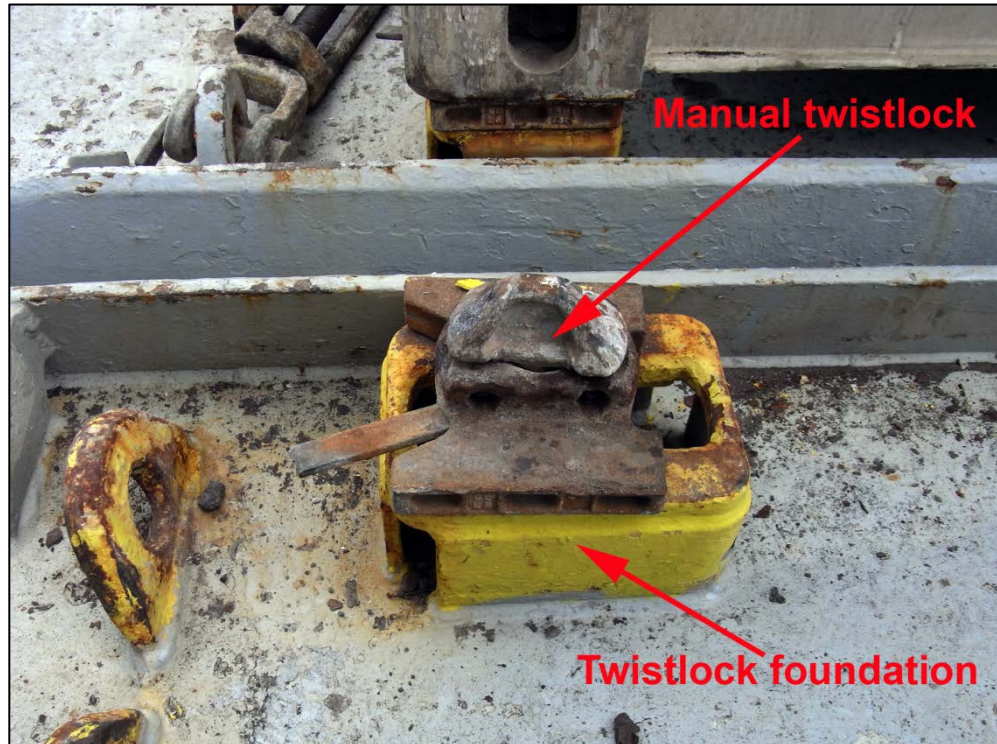
'Semi-automatic' twistlocks operate on the same principle as manual twistlocks but they are fitted to the corner casting of a container on the wharf and when the container is loaded onto the ship, the semi-automatic twistlock 'self locks'.

The bottom level (tier) of containers on board *Vega Gotland* are secured to the hatch covers using manual, left-hand locking twistlocks, which sit in elevated

foundations welded to the hatch cover or fixed pedestals (Figure 3). Semi-automatic twistlocks are used to secure the containers in all the remaining tiers¹⁰.

The twistlock foundations are welded to the hatch covers and stand 110 mm off the hatch covers. The twistlocks and foundations have a nominal breaking load of 500 kN (about 50 tonnes) in tension and 420 kN in shear.

Figure 3: A manual twistlock seated in a foundation



Once a bottom tier container has been lifted on board and correctly positioned on the twistlocks, the twistlocks are manually locked. The portainer spreader¹¹ can then release the container and the spreader can return to the wharf to lift another container.

When loading in a container bay is complete, the containers are lashed in accordance with the ship's lashing plan. The standard lashing arrangement involves fitting lashing rods to the top corners of the bottom containers, and to the bottom corners of the second and, sometimes, the third tiered containers, depending on the weight of the container stack. A turnbuckle is then connected to each lashing rod and a strong point on the ship's hatch cover or structure (Figure 4b). The turnbuckles are then tightened to firmly secure the containers.

¹⁰ Because the unlocking mechanism of semi-automatic twistlocks are not designed to be used at deck level, semi-automatic twistlocks were not used on the bottom tier.

¹¹ A device used for lifting containers and unitized cargo. When used for containers, a spreader has a locking mechanism (a twistlock) at each corner that attaches to the top four corners of the container.

Twistlock foundation positioning on the hatch covers

On most cellular container ships, the twistlock foundations (or similar) for adjacent containers sit directly next to each other (Figure 4a). This allows a container being loaded to be ‘butted’ up against an already loaded container and slid into position on the twistlock.

The positioning of the twistlock foundations on *Vega Gotland* differ from this in that the foundations do not sit directly next to each other. There is a gap of about 150 mm between each foundation (Figure 4b) to allow for the carriage of over-width cargo in flat rack containers.

Figure 4a & b: Containers positioned directly next to each other and *Vega Gotland*’s containers positioned apart



This spacing generally requires the container being loaded to be manoeuvred into position, either manually or by the portainer driver, as the container cannot be ‘butted’ up against an already loaded container. Consequently, loading of containers on board *Vega Gotland*’s hatch covers can take longer than other container ships and more manual intervention is required during the loading process.

1.2 Patrick Terminal, Port Botany

Port Botany is located about 12 miles¹² south of the entrance to Sydney Harbour. About 70 per cent of Sydney’s cargo is handled through the port and in 2011, the facilities there included two container terminals and a bulk liquid berth.

Brotherson Dock is the area within Port Botany in which the container terminals are located. The swinging basin at Brotherson Dock is dredged to 14.4 m.

Patrick Terminals (Patrick) is Australia’s largest operator of container terminals and operates one of the container terminals at Brotherson Dock (Figure 5). The terminal has a capacity of 1,300,000 TEU. The wharf frontage is 1,050 m long and incorporates four berths. The wharf is serviced by seven portainers: five panamax¹³ and two post-panamax¹⁴.

¹² A nautical mile of 1852 m.

¹³ Portainer cranes that can handle a ship with a maximum of 13 containers across the deck.

¹⁴ Portainer cranes that can handle a ship with a maximum of 18 containers across the deck.

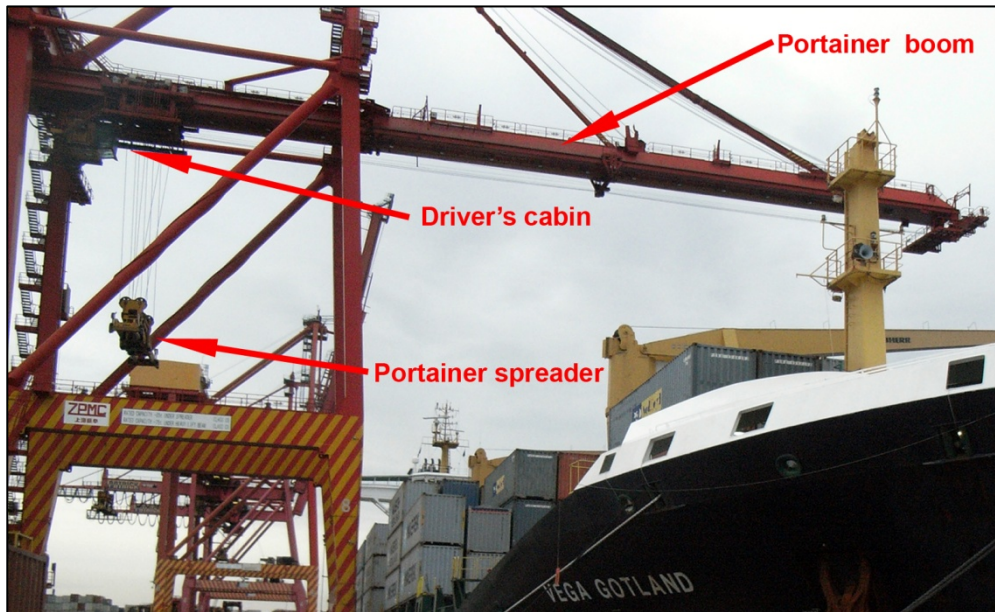
Figure 5: The Patrick container terminal at Port Botany



The terminal operates 24 hours a day and stevedoring personnel work three 8 hour shifts: 0600 to 1400, 1400 to 2200 and 2200 to 0600.

Containers at the terminal are stacked in a container park, adjacent to the wharf area, which has railway and road access (Figure 5). Containers are transported around the terminal using straddle carriers¹⁵. When a container is to be loaded onto a ship, it is transported by a straddle carrier from the container park to the quayside and placed beneath the appropriate portainer. The portainer spreader is then lowered onto the top of the container by the portainer driver, who is seated in a cabin suspended under the portainer's boom (Figure 6). The container is then lifted clear of the wharf and loaded onto the ship.

Figure 6: A Patrick portainer, showing the driver's cabin and spreader



¹⁵ Vehicles which straddle their load and connect to the top lifting points via a container spreader.

1.2.1 The 1600 to 2200 shift staff on 28 March 2010

At the time of the accident, containers were being loaded on board *Vega Gotland* using one portainer and there were nine stevedores on board: a deck team leader and a lashing team (lashers), made up of a team leader and seven trainee lashers.

The deck team leader was responsible for supervising the loading of the ship, locking any manual twistlocks, supervising the portainer driver and the 'pin man'¹⁶.

The deck team leader had worked for Patrick for 10 years, initially as a casual lasher. He had completed his team leader training and had been working as a deck team leader for over 5 years. He had undergone all of the Patrick safety and induction training and had completed occupational health and safety (OH&S) refresher training in March 2006.

The portainer driver had worked for Patrick for 20 years, the last 15 as a portainer driver. He had undergone all the Patrick safety and induction training and had completed OH&S refresher training in March 2006.

The lashing team leader had worked for Patrick for about 6½ years. He completed his induction training in 2003 and then qualified as a straddle carrier driver. He had completed his team leader training in September 2007 and had worked both as a deck team leader and a lashing team leader since that time.

The trainee lashers had worked for Patrick since November 2009. They had completed their induction training and were in the process of gaining on-the-job experience.

1.2.2 Stevedore training

Patrick has a training program in place for its new and operational employees. The training includes classroom instruction, hands-on practical training and supervised on-the-job experience.

New employee training

All new Patrick employees are required to undergo classroom based induction training before they are permitted to work inside the terminal. The induction training 'provides an overview of the foundations of Patrick, its infrastructure (procedures and systems that are in place) and an overview and practical application of the more technical aspects of the role'¹⁷ that new employees will come across during their initial time in the terminal.

The induction training involves general employment at Patrick, its policies and procedures (including OH&S), terminal operations, emergency response, dangerous goods and hazardous substances, accident prevention and personal protective equipment. It also covers manual handling, the operations and safety associated with terminal equipment, lifting equipment, the lashing and unlashings of containers and how Patrick works with commonwealth and state authorities,

¹⁶ A stevedore on the wharf whose task it was to position the semi-automatic twistlocks in a container's bottom corners before loading onto the ship.

¹⁷ Patrick's terminal induction elements training material for new employees.

The training specifically covers recognised safety practices of not working, standing or walking under or in the path of a suspended container or load (working under the hook), to 'never stand between a fixed object, such as [a] cargo stack, and the likely path/swing of the load' and to 'always ensure that in the event of sudden load/spreader swing you have a clear area behind you'.

New employees are assessed at the end of the classroom induction training to ensure they understand the importance of these safety practices.

The classroom training is followed by practical instruction in the use of lashing equipment. This enables a new employee to work in an entry level position, as either a lasher or a pin man. The lasher practical instruction includes manual handling, the use of the equipment and following the safe work instructions (SWIs) for the task. The pin man practical instruction covers working in an elevated cage, working with twistlocks and following SWIs. Each trainee then undertakes these tasks under supervision and records them in a logbook until they are considered to be competent to work in these positions.

Specific roles, such as a straddle carrier driver or portainer driver, require further specialised training.

Team leader training

Experienced stevedores can be chosen by Patrick management to undergo team leader training. According to Patrick's team leader training workbook:

In order to maintain safe and efficient operations and to ensure a high standard of cargo care, every stage of stevedoring operations are supervised by highly trained personnel. The Team Leader is the "front line" supervisory person. He/she may have a diverse and extensive range of duties and responsibilities and provide an important link between the management and the operational personnel.

To be able to fulfil the role of a team leader, a supervisory position, a stevedore is required to undergo specific training. The team leader training places more emphasis on personnel management, supervision and principles of leadership. This includes refresher training in Patrick policies, general safety practices, OH&S policies and procedures (including duty of care), duties and responsibilities, and shift procedures. It also includes site inspection for hazards, radio procedures, handing over a shift, planning and use of SWIs.

This reinforcement included the fact that no stevedore was to work under an operational crane¹⁸ and that the people they are supervising should not be allowed to stand between loads and fixed objects, particularly in confined spaces¹⁹.

The training is followed by supervised experience until the trainee team leader is deemed to be competent.

The actions of the team leaders are overseen by the shift manager. There is one shift manager on duty on each shift. That person is responsible for operations throughout the terminal, both ashore and on board all the ships which are berthed at the terminal.

¹⁸ Patrick's leading hand lasher handout, version 1 of 2007, page 30.

¹⁹ Patrick's team leader workbook, version 2 of 2009, page 59.

Lashing team leader training

This specific training is intended to add to the knowledge and experience the stevedore has acquired during his time in lashing teams.

In addition to the generic team leader training, prospective lashing team leaders undergo more specific training in that area of operations. It covers accident prevention, personal protective equipment, regulations, emergency procedures, the type and use of lashing equipment, manual handling, stowage plans and bay numbering on ships. It also covers the operations and safety associated with terminal equipment, lifting equipment, the lashing and unlashings of containers and how Patrick works with commonwealth and state authorities.

The general safety training includes types of lashing accidents that might occur when lashing containers (hit by falling lashing gear, tripping on lashing gear left lying on the deck, falls, crushed hands, fingers or feet and hitting head). It also emphasises that Patrick employees are not to work under an operational crane.

1.3 The accident

At 1100²⁰ on 28 March 2010, *Vega Gotland* arrived off Port Botany, New South Wales, after a voyage from Melbourne, Victoria. At 1124, a harbour pilot boarded the ship for its passage to the berth. Shortly afterwards, the ship entered Port Botany and by 1218, it was all fast starboard side to berth number 2A at Brotherson Dock.

At 1254, cargo operations commenced using two portainer cranes.

At 1412, following a terminal safety meeting, the afternoon shift²¹ of stevedores started work. At the beginning of the shift, the deck team leader had been told that *Vega Gotland* was due to sail at 2200 and that there was another ship due which would occupy some of the wharf where *Vega Gotland* was currently berthed. Consequently, the shift would need to try and complete cargo work on board the ship by that time. However, the shift manager would, if necessary, change the ship's departure time if it became apparent that cargo work would not be completed for a 2200 departure.

At 1742, the stevedores went ashore for their evening meal break.

At about 1835, following a review of cargo operations, the shift manager revised *Vega Gotland's* sailing time to midnight.

At 1842, loading resumed on board *Vega Gotland* in Bays 12 and 24 using two portainers.

At about 1845, just before the lashing team left the meal room, the shift manager spoke with the lashing team leader about the requirements for lashing the containers on board *Vega Gotland*. The shift manager told the team leader which bays would be clear for lashing when the stevedores returned from the meal break. He also pointed out the faces²² of the containers which could not be lashed because the portainer would be loading containers in the bay next to them.

²⁰ All times referred to in this report are ship's time, Coordinated Universal Time (UTC) +11.

²¹ The 1400 – 2200 shift.

²² Forward and aft end of containers.

The discussion also included noting that the lashing of the ship would probably not be completed by the end of the shift. With this in mind, the shift manager asked the lashers to lash what they could so that when the shift ended, the lashing was as up to date as possible.

Following the meeting, the team of lashers, under the direction of the lashing team leader, went on board the ship. When they got there, they prepared to lash the containers which were being loaded on deck in Bay 24.

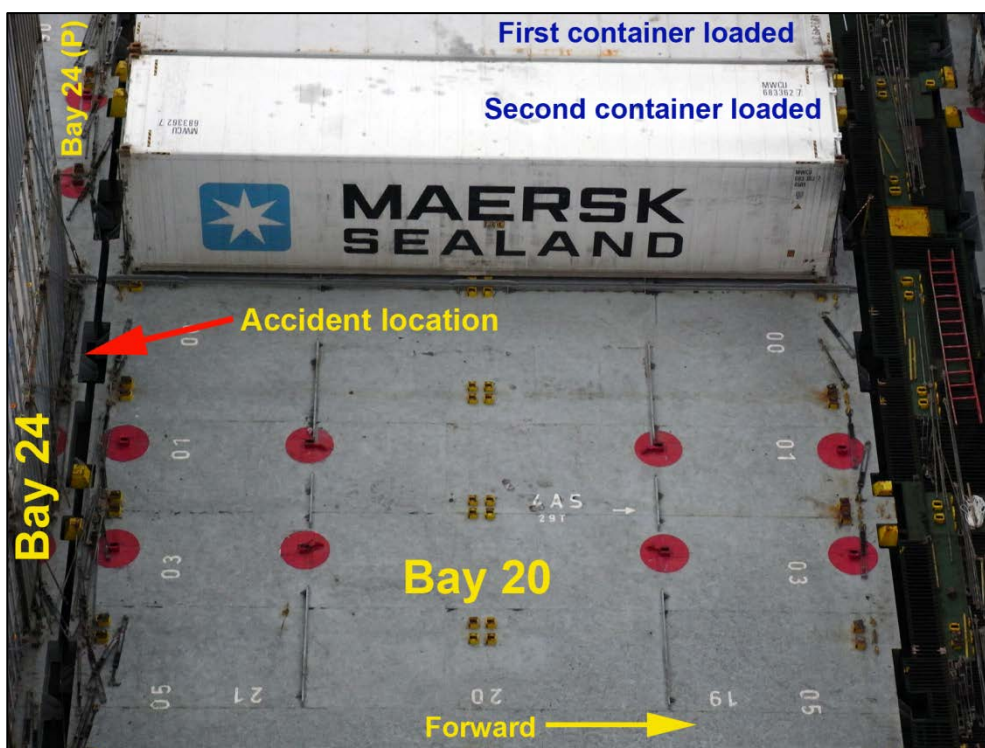
The lashers were separated into two teams of four men. One team went to the after end of Bay 24 and the other team went to the forward end of the bay. The two teams began putting lashing rods and turnbuckles in place. The lashing team leader was working with, and supervising, the team at the forward end of Bay 24.

At about 1902, the loading of containers on the deck in Bay 24 was completed and the portainer moved forward, clear of the bay.

At 1907, the forward portainer, which was loading Bay 12, moved from *Vega Gotland* to a ship berthed ahead. The after portainer that had finished loading the containers on deck in Bay 24 moved forward and continued loading containers on deck in Bay 12.

At 1911, loading of Bay 12 was completed and the portainer moved aft to begin loading FEU refrigerated containers on deck in Bay 20. Just before cargo loading started in Bay 20, the deck team leader told the lashers working at the forward end of Bay 24 to move clear as they were shortly going to be loading containers there. The four lashers stopped putting the lashings on the containers and moved to the port side of that bay, which was clear of containers (Figure 7).

Figure 7: View of Bay 20 from the portainer cabin



At 1913, the first FEU was loaded onto the port side hatch cover of Bay 20 and the deck team leader locked the forward twistlocks. However, because of the ship's stern trim, the container did not sit properly on the after twistlocks so the deck team leader instructed the portainer driver to lift the container slightly so that it could be manoeuvred over the after twistlocks. This was done and the team leader instructed the portainer driver to lower the container into its final position.

The deck team leader walked aft and locked the after twistlocks. He then returned to the forward end of the bay in preparation for loading the second container which was being picked up off the wharf.

At 1915, the second container was landed onto the port side hatch cover. Once again, the container did not sit properly on the after twistlocks and the portainer driver manoeuvred the container so that it did. While the deck team leader was at the after end of the container locking the twistlocks, he saw that the lashing team leader was already putting lashing rods on the first container. Hoping to save some time, the deck team leader asked the lashing team leader if he would lock the remaining after twistlocks when the containers had been loaded on the hatch covers. The lashing team leader agreed.

By this time, the lashing team leader and one of the lashers had started putting lashing rods on the after end of the second container loaded in Bay 20. Two other lashers had moved to the forward end of Bay 20 to start lashing the forward end of the containers. During the placement of the lashing rods on the containers, the lasher working with the team leader received a call on his mobile telephone. He answered the call and proceeded to have a conversation while he assisted the team leader. After the lashing rods were put on the second container, the lasher stood back and continued his conversation on the telephone.

At 1917, a third container was lowered into position, this time onto the starboard side hatch cover in Bay 20 (Figure 7). As with the first two containers, the third container did not sit properly on the after twistlocks. The deck team leader locked the twistlock at the forward inboard corner of the container, so that there would be a point around which the container could pivot horizontally. He then moved away from the container, and stood on the forward end of the hatch cover, well to starboard so that the portainer driver could see him clearly. He asked the portainer driver to lift the container slightly so that it could be positioned over the after twistlocks.

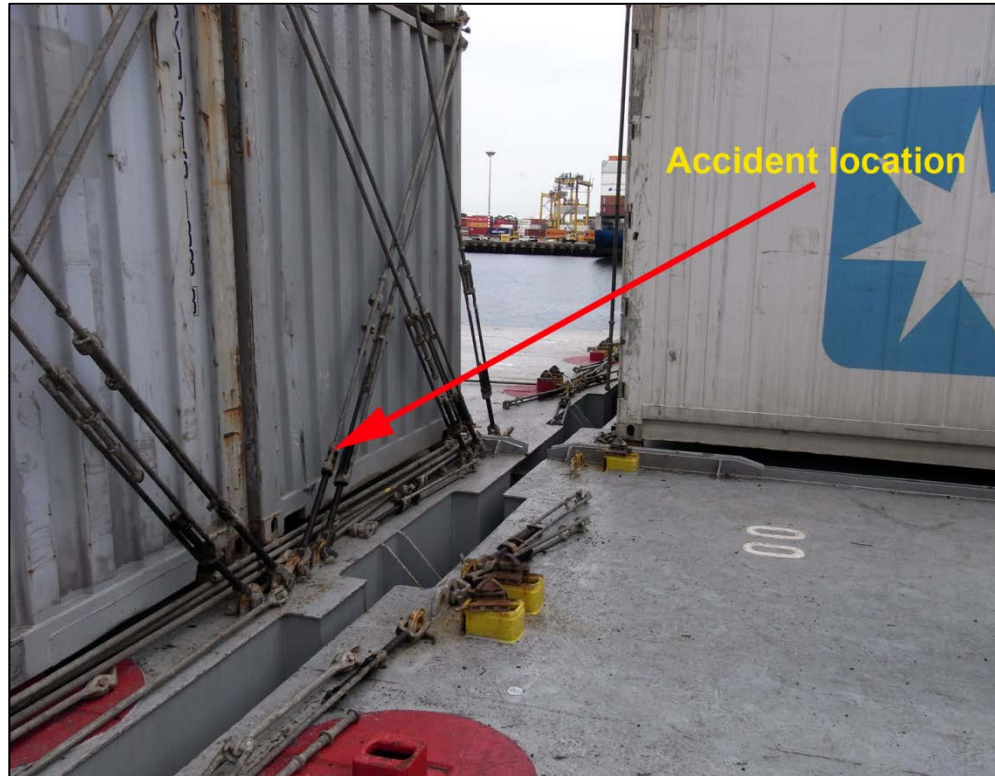
The lashing team leader moved towards the third container, in preparation to lock the after twistlocks. He stood at the after end of the hatch cover, between the container which was being loaded and a FEU which had been loaded in Bay 24 (Figures 7 and 8).

When the portainer driver lifted the container slightly, the deck team leader felt the starboard hatch cover lift. He immediately shouted to the portainer driver, via his hand-held radio, to stop lifting. However, just as he did so, the inboard foundation holding the locked twistlock failed and container swung.

The lasher, who was still talking on his mobile telephone, saw the container begin to swing. He yelled to the lashing team leader to get out of the way. However, the team leader did not have enough time to get clear and was hit by the swinging container and crushed between it and the container in the adjacent Bay 24.

The deck team leader and the lasher rushed over to the lashing team leader and attempted to find a pulse. When told of the accident, the other lashers also came to the accident site to see if they could help.

Figure 8: Accident location between Bays 20 and 24



The portainer driver, who was unaware of the presence of the lashing team leader until after the container had struck him, placed the container back on the wharf.

One of *Vega Gotland*'s seamen heard the loud bang from the area where containers were being loaded and came up onto the walkway between Bays 20 and 16 to investigate. When he saw the stevedore slumped beside the container, he contacted the third mate on his hand-held radio. The third mate went to Bay 20 to see what had happened. He then informed the ship's master about the accident.

Shift management ashore were advised and at 1920, all operations in the Patrick terminal were suspended and shore side emergency services were contacted. By 1937, terminal medical staff and an ambulance had arrived on the wharf. Paramedics were at the lashing team leader's side shortly afterwards. However, the team leader had received fatal injuries when he was crushed between the two containers.

During the rest of the evening, officers from other agencies, including the New South Wales Police Service, the Australian Maritime Safety Authority and the WorkCover Authority of New South Wales arrived on board the ship to initiate investigations into the accident.

At 2200, *Vega Gotland*'s master notified the ship's owners of the accident and at 2255, the police took the lashing team leader ashore.

Cargo operations on board *Vega Gotland* did not resume and at 2123 on 30 March, the ship departed Brotherson Dock, bound for Auckland, New Zealand. Cargo operations at Patrick's terminal remained suspended until 2200 on 30 March.

2.1 Evidence

On 29 March 2010, investigators from the Australian Transport Safety Bureau (ATSB) attended *Vega Gotland* while it was berthed at Patrick Terminals (Patrick), Port Botany. The master, the third mate and the duty seaman were interviewed and each gave their account of the accident. Copies of relevant documents were obtained, including log book entries and cargo records. The investigators also took photographs of the accident site and of the relevant container.

On 29 March, the ATSB investigators also interviewed Patrick's national safety, health and environment manager, who had travelled from Melbourne following the accident.

On 11 and 26 May, the ATSB investigators interviewed the Patrick stevedoring personnel who had been involved with container operations on board *Vega Gotland* on 28 March 2010. They provided their accounts of the accident.

Further relevant information was later provided by Patrick, the New South Wales Police, the Australian Maritime Safety Authority, the WorkCover Authority of New South Wales and the Maritime Union of Australia.

During the investigation, in order to conduct a failure analysis, the ATSB took possession of the twistlock foundation top, and the manual twistlock which was still locked in it, from the WorkCover Authority of New South Wales.

2.2 The accident

At about 1918 on 28 March 2010, the stevedore lashing team leader was killed instantly when he was crushed between two containers during loading operations on board *Vega Gotland*. Immediately before the accident, he was standing at the after end of a container being landed, waiting to lock the after set of twistlocks on the hatch covers in Bay 20, when a twistlock foundation, which was securing the forward end of the container to the hatch cover, failed while the container was being lifted to reposition it. The container swung aft and struck the lashing team leader.

At the time, the hatch cover on which the container was being landed was not properly secured and, because of the nature of the operation, the portainer driver was not aware of the presence of the lashing team leader until after the accident.

A post mortem revealed that the team leader died as a result of blunt force/crush injuries of the head and trunk, consistent with being caught between the swinging container and another container in Bay 24. A toxicology report did not reveal any evidence of alcohol in the team leader's body. However, according to the post mortem report, testing could not be undertaken for:

immunoassay screening for amphetamines, cannabinoids, cocaine, benzodiazepines and opiates or for comprehensive drug screening.

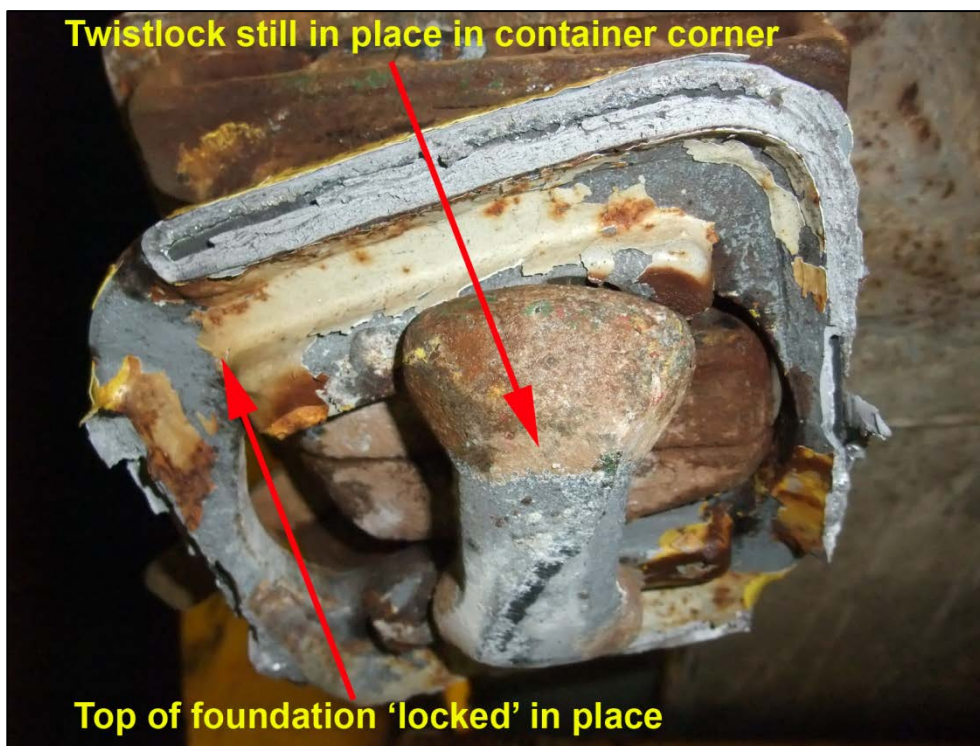
During the course of the investigation, Patrick management and stevedoring personnel stated that, although there was another ship waiting for *Vega Gotland* to depart, there was no pressure on the stevedores to complete cargo operations on

board *Vega Gotland* before the end of the afternoon shift at 2200 on 28 March. Consequently, loading and lashing operations on board *Vega Gotland* were following the usual practices within the terminal.

2.3 The failure of the twistlock foundation

The container which swung aft was secured to *Vega Gotland*'s hatch cover by a twistlock which had been locked into a single twistlock foundation (Figure 9). At the time of the accident, the ship was 5 years old. The ship and the container fittings on its hatch covers were well maintained and in good condition. Consequently, the strength and effectiveness of the foundation that separated was not affected by corrosion. The twistlock foundations had been welded in place during the construction of the hatch covers and had not been modified or replaced since the ship entered service.

Figure 9: Top of the twistlock foundation that parted



The top of the twistlock foundation was examined by ATSB technical investigators to determine how and why the MacGregor TF-11 twistlock foundation failed. The full report of this failure analysis is contained in Appendix A and is summarised here.

The technical examination determined that the failure of *Vega Gotland*'s twistlock foundation assembly was consistent with its exposure to gross overstress conditions. The weld fractures and deformation of the hardware (the twistlock and the twistlock foundation top) were found to be consistent with a combination of tensile, bending and shear loads generated during the reported asymmetric lifting of the partly secured container and the unsecured hatch cover. The angle of the hatch cover, due to the ship's stern trim, applied a magnified leverage to the foundation and this contributed significantly to the failure of the welds.

While the ATSB's technical examination found that the welds between the top plate and the side plates of the twistlock foundation were not in compliance with MacGregor's engineering and design specifications, the deficiencies were not at a level likely to have had a major detrimental effect on the overall strength of the assembly.

2.4 Container handling on board *Vega Gotland*

2.4.1 Working near containers being loaded

On 'conventional' container ships (those on which the containers are 'butted' up against each other), good practice dictates that manual twistlocks are locked after the portainer spreader has been unlocked from the container just loaded. This means that personnel can stand well clear of the container while the spreader is still attached. Consequently, personnel only get close to the container when it has been landed and there is no risk of it moving.

However, the spacing of the twistlock foundations on *Vega Gotland*'s hatch covers meant that each container had to have a degree of manual intervention before it could be successfully landed and secured. Therefore, it was necessary for the stevedores to be in close proximity to a container while it was still locked to the spreader and being manoeuvred by the portainer. This meant that the risks of the stevedores coming into contact with a container that could move unexpectedly were higher than on 'conventional' container ships.

Vega Gotland was not the only ship to have berthed at the Patrick's terminal with this type of arrangement on its hatch covers. In all cases, the stevedores had loaded the deck cargo in the same way.

On 28 March, the lashing team leader was in a position at the after end of Bay 20 which allowed him easy access to lock the twistlocks as soon as the container was landed on them. However, he had moved into that position before the container had been fully landed and released from the spreader and therefore had placed himself in a position of danger in the small space between the moving container and the adjacent one already loaded.

2.4.2 Unsecured hatch cover

When the portainer driver lifted the container to reposition it over the after set of twistlocks, the deck team leader felt the starboard hatch cover lift under his feet. This indicated that the hatch cover was not properly secured before containers were loaded onto it.

The Bay 20 port and starboard hatch covers on board *Vega Gotland* were each secured in place by six semi-automatic twistlocks, two each at the forward and after ends and one each on the port and starboard side. The purpose of the twistlocks was to make the hatches weathertight. Using semi-automatic twistlocks for this purpose also sped up the loading process as there was no need for manual securing devices such as cleats (dogs) to be used.

To properly secure the hatch cover, the semi-automatic twistlocks needed to be 'reset' so that they would lock as soon as the hatch cover was landed back in place.

In the case of *Vega Gotland*, because this task was not seen as being directly related to loading cargo, the task was performed by the ship's crew after the hatch cover had been landed on the wharf by the portainer and not by the stevedores.

In submission, the ship's owner stated that:

Before the cargo operation commenced, the foreman stevedore met with the vessel's chief officer and gave him instructions with respect to the safety policy of the Terminal. Those instructions included that no one from the crew was allowed to work on deck while cargo operations were in progress. We believe that to be a standard and proper instruction to give. As a consequence, it was not possible for crew members to secure the hatch lids into position whilst cargo operations were under-way.

Therefore, because cargo operations were still being conducted on Bay 20 at the time of the accident, this task was not completed for the bay's starboard hatch cover and when the first container to be loaded in that bay was secured to the hatch cover by a single forward twistlock, the hatch cover lifted as the container was lifted. As a result of the excessive stresses generated during the lifting of the partly secured container and the unsecured hatch cover, predominantly because of the magnified leverage to the foundation which came about because of the angle of the hatch cover resulting from the ship's stern trim, the twistlock foundation failed.

2.4.3 Portainer driver situational awareness

Visibility of *Vega Gotland*'s hatch covers from the portainer cabin was restricted. With a container suspended under the spreader, due to perspective (or field of view) the portainer driver had virtually no visibility of the forward and aft twistlock foundations while he was lowering the container into position. He was able to see the forward and after ends of the hatchcover/walkways only when the container was landed in position (Figure 10). Therefore, he relied on the directions provided by the deck team leader for container positioning.

With this in mind, when loading a container in Bay 20, the deck team leader moved to a position on the hatch cover so that he was in clear view of the portainer driver at all times.

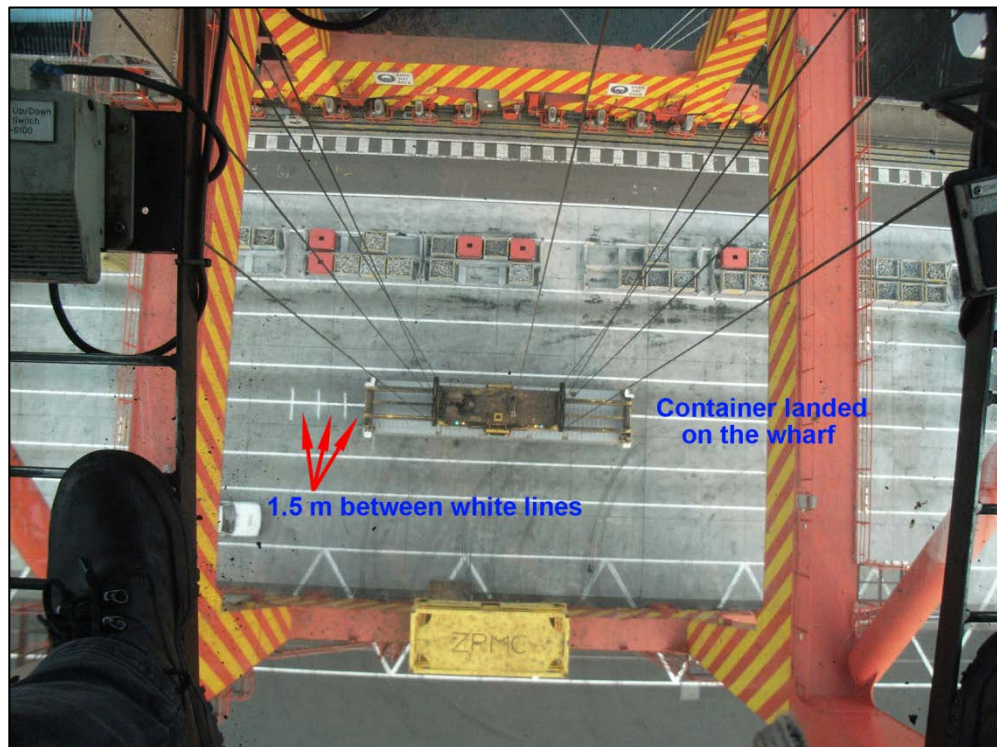
It was the usual practice at Patrick for the deck team leader to manually lock any deck twistlocks which were not 'self-locking'. However, on board *Vega Gotland* on 28 March, the deck team leader had asked the lashing team leader to help him by locking the twistlocks at the after end of Bay 20.

Following the request, the deck team leader did not tell the portainer driver that there would be two men working around the containers as they were being loaded. Consequently, the portainer driver was not aware that there was someone working at the after end of Bay 20. Therefore, a critical defence against an accident was inadvertently circumvented as the portainer driver was only looking for one man to be safely clear on deck as he positioned each container.

The usual practice when loading containers is that if the portainer driver cannot see the nominated number of personnel in the vicinity of loading, from his position in the portainer cabin, he will not land the container. On 28 March, had the portainer driver been aware that there were two men working in the vicinity of Bay 20, he could have made sure that two men were clearly visibly to him, and therefore clear of any potential danger, before he attempted to land the container in Bay 20. This

would have meant that the lashing team leader would have needed to be in a position well clear of the container before it was fully landed and therefore not positioned where he was.

Figure 10: View from the portainer cabin with a 40 foot container attached to the spreader



2.4.4 Unsafe work practices during cargo operations

The lashing team leader was known to be a hard-working employee who was willing to help other stevedores and who was keen to 'get the job done'. The fact that he readily agreed to lock the after twistlocks when the deck team leader asked him on 28 March was a good illustration of this.

However, while on shift in the past, he had been seen to follow some unsafe work practices, such as working under a container. While he was never seen to put any other person's safety at risk, the consequence of following these unsafe practices himself could, and eventually did, put his personal safety at risk.

The lashing team leader was not the only senior stevedore who had been observed at times not following the documented safe work instructions (SWIs) and using unsafe work practices. There could have been a number of reasons these stevedores undertook this course of action, the most likely being that these actions had become so routine they were no longer aware they were doing something 'unsafe'.

The lashing team leader had been employed by Patricks since 2003 and had been a team leader since 2007. He could, therefore, be considered to be very experienced in the lashing task he was undertaking on 28 March. Other team leaders who had been observed by other stevedores not following the Patrick SWIs probably had similar or more time in the stevedoring industry.

It is probable that the lashing team leader, and other more senior stevedores, had developed a false sense of security about the dangers associated with loading and lashing containers. As a result, these stevedores may have become complacent about the risks associated with the task.

Bengt Schager, in his book *'Human Error in the Maritime Industry – How to understand, detect and cope'*²³ discusses the issue of complacency in the maritime industry. This concept can easily be applied to the stevedoring industry.

Complacency

...is a state of mind. It is an unconcerned attitude, e.g. in connection with the presence of danger and risk, where individuals behave and think in a routine-like mode, anticipating an uneventful and ordinary development of the present situation.

Complacency is a passive state, not an active one, and no one chooses to be complacent. It creeps into one's mind imperceptibly. Individuals are therefore unaware of being complacent and would, if asked, reassuringly deny it. Instead, individuals would probably justify their state of mind as rational, realistic, reasonable and in line with situational requirements, as well as a sign of experience.

Complacency can lead to ... a false sense of security as well as a false sense that the situation is under control when it isn't. It can furthermore lead to deficient risk assessment or to repress risks and not paying proper attention to what one is engaged in.

It is possible that the lashing team leader viewed the locking of the twistlocks as a mundane task, one which did not require any level of conscious thought because he had done it so many times before with no adverse consequences. He had, therefore, probably become desensitised to the risks associated with loading and lashing containers and this resulted in him positioning himself at the after end of the container being loaded, not thinking about anything except the container being landed so that he could lock the after twistlocks.

2.5 Safety zone identification

On the evening of 28 March, the shift manager told the lashing team leader not to work on the 'faces' of containers adjacent to where the portainer was operating. However, at the time of the accident, while the lashers were following this instruction, they were lashing the containers on deck in Bay 20 as soon as a container had been landed. This meant that they were lashing next to another container which was being loaded (Figure 8). In other words, the lashers were working in very close proximity to a moving container.

At the time of the accident, Patrick had no policy or procedure in place which provided its stevedores with any guidance about where they should or should not work in relation to containers being loaded or discharged; i.e. a 'no go' or safety zone. Consequently, there was no formalised guidance about lashing in container bays immediately forward or aft of a bay where containers were being loaded or discharged.

²³ Marine Profile, Sweden, 2008, pages 100 - 112.

By comparison, in March 2009, the United States Department of Labor's Occupational Safety and Health Administration (OSHA), in alliance with the National Maritime Safety Association (NMSA), published a container lashing safety tip sheet. Their intention in publishing the tip sheet was to provide a quick reference for lashers and their supervisors prior to the start of any lashing task.

The tip sheet gives clear guidance about how close a lasher should work near a container being loaded:

It is best practice not to lash or unlash any closer than at least 3 container widths away from any operation. (Note: this is a minimum distance. Local port areas may have different rules on this separation distance.)

With regard to Patrick operations, no evidence was provided to the ATSB during the investigation to indicate whether the training provided to soon-to-be team leaders, either deck or lashing, contained any guidance to on how close to loading or discharge operations a lashing team should be.

Consequently, it is likely that when the newly trained team leaders assumed that role during cargo operations, they relied on the basic guidance provided in the SWIs and what they had practiced and observed in the past, when they were members of lashing teams.

As a result of the absence of guidance material and training provided by Patrick regarding where a team of lashers was to work, it is likely that the lashing team leader would rely on his knowledge and experience to make that decision, rather than an appropriately risk analysed system approach.

The ATSB was advised that immediately following the accident Patrick introduced a 'restricted zone'²⁴ around container bays where loading and discharge operations are being carried out on board a ship. This zone is bound by the fore and aft faces of containers stowed in the bay where containers are being worked, the aft faces of containers stowed on the bay immediately forward of that bay and the forward faces of the containers stowed on the bay immediately aft of the bay being worked. The restricted zone does not cover the inboard or outboard fore and aft access ways on the ship.

According to guidance provided by Patrick to its stevedores regarding the restricted zone²⁵:

Lashing and container locking unlocking will not be performed in the restricted zone whilst container crane operations are taking place.

The Team Leader may need to be positioned within the Restricted Zone depending on the operation being conducted and the required level of visibility. In these circumstances, the Team Leader will continue to stand well clear of the path of the load and maintain radio contact with the crane driver regarding position and movement.

In the event that Patrick personnel other than the Team Leader have to enter the restricted zone it is to be on application to the Team Leader attached to the crane working the particular bay. The Team Leader will assess the request, in conjunction with the Shift Manager as necessary, and grant or deny access. This

²⁴ Patrick document SO0110, dated 30 March 2010.

²⁵ *ibid.*

decision will be communicated to the rest of the crane team. In the event that access is granted container crane operations within the Restricted Zone will cease for the duration of such access.

All Patrick personnel shall be reminded of the Restricted Zone concept and it shall be incorporated into tool box talks, lashing and deck work training programmes.

These requirements apply to stevedores, ships' crew and all visitors on board a ship.

The stevedore deck team leader is responsible for ensuring that the 'restricted zone protocol' (RZP) is enforced. To assist the team leader in this, Patrick has developed a 'shipboard team leader protocol' which is designed to

ensure that shipboard work performed in conjunction with container crane operations continues to be performed safely. Integral to the team leader protocol is the reinforcement of a restricted zone surrounding the container crane which will be overseen by the team leader.²⁶

To support the RZP, induction training, employee handbooks and the shipboard team leader and lashing and unlashings operations SWIs²⁷ have been revised and now contain extensive reference to the RZP.

2.6 Safety management

2.6.1 A system of safety

A system of safety is a feature of an industry or sector rather than of an organisation and is defined by the shared safety objectives of key stakeholders resulting in a systemic approach to reducing risk in the workplace. Complementary roles and operations of stakeholders promote the system and introduce multiple layers of defences to prevent adverse occurrences.

These layers of defence start at the regulatory level, with laws and codes of safe practice, pass through industry bodies all the way down to the training of personnel, safe operating procedures and the mindset of people involved in the operations 'at the coal face'.

While a system of safety is more than one specific organisation, the attitudes of personnel at all levels of individual organisations are vital for the ongoing success of any system of safety. The combined effect of legislation and its effective implementation in the workplace, and the attitude of personnel towards safety, enhance both the organisational culture²⁸ and safety culture²⁹ within an organisation.

²⁶ Patrick document SO0210, dated 30 March 2010.

²⁷ Patrick documents SSA0108 and SSA0204, dated 12 May 2010 and March 2011 respectively.

²⁸ Can be defined as the vision, values, norms, leadership styles, interpersonal behaviours and behavioural expectations and norms of an organisation.

²⁹ Can be described as the values and practices that management and personnel share to ensure that risks are always minimised and mitigated against to the greatest degree possible.

2.6.2 Occupational health and safety legislation

The New South Wales *Occupational Health and Safety Act 2000* (OH&S Act) and the associated *Occupational Health and Safety Regulation 2001* (the regulations) were in force at the time of the accident and applied to the Patrick terminal.

Obligations placed on Patrick

Part 2 of the OH&S Act³⁰ required Patrick to, so far as reasonably practicable, ensure the health, safety and welfare of all its employees while they were at work. That duty extended to the following:

- (a) ensuring that any premises controlled by the employer where the employees work (and the means of access to or exit from the premises) are safe and without risks to health,
- (b) ensuring that any plant or substance provided for use by the employees at work is safe and without risks to health when properly used,
- (c) ensuring that systems of work and the working environment of the employees are safe and without risks to health,
- (d) providing such information, instruction, training and supervision as may be necessary to ensure the employees' health and safety at work,
- (e) providing adequate facilities for the welfare of the employees at work.

The requirements contained in Part 2 of the OH&S Act were augmented by the OH&S regulation. This imposed additional obligations on Patrick so that the company could:

...identify foreseeable hazards that might arise from the conduct of the employer's undertaking, to assess the risks of those hazards and to eliminate the risks or, if not reasonably practicable to do so, to control the risks.³¹

Chapter 2 (9) of the regulation elaborated on the type of hazards which Patrick must identify and Chapter 2 (10) through to (12) provided direction on the risk assessment and the elimination or control of those risks that must be undertaken in response to the identified hazards.

Chapter 2 (13) required Patrick to provide instructions, training and information to its employees, including the notification of any identified risk and any information, instruction and training necessary to ensure the person's health and safety.

Importantly, Chapter 2 (16) of the regulation required Patrick to:

...obtain such information as is necessary to enable the employer to fulfil the employer's responsibilities under this Regulation with respect to the following:

- (a) identifying hazards,
- (b) assessing risks arising from those hazards,
- (c) eliminating or controlling those risks,

³⁰ Part 2 (Duties relating to health, safety and welfare at work), Division 1 Section 8 (Duties of employers).

³¹ Note to Chapter 2 (Places of work – risk management and other matters) of the regulation (page 33).

(d) providing information.

In essence, the OH&S Act and regulation required Patrick to have an OH&S risk management framework in place for its operations so that workplace hazards could be identified and any risks to its employees either eliminated or reduced to as low as reasonably practicable (ALARP). It also required Patrick to make sure that its employees were aware of any risks and then provide them with training and information/guidance which could assist them with being able to be aware of the hazards and risks and how to work safely in the terminal.

Obligations placed on employees

To assist with fostering a safe working attitude within a company's workforce, and therefore contribute to workplace safety, Section 20 of the OH&S Act (Duties of employees) stated:

(1) An employee must, while at work, take reasonable care for the health and safety of people who are at the employee's place of work and who may be affected by the employee's acts or omissions at work.

(2) An employee must, while at work, co-operate with his or her employer or other person so far as is reasonably necessary to enable compliance with any requirement under this Act or the regulations that is imposed in the interests of health, safety and welfare on the employer or any other person.

This meant that there was a statutory obligation for Patrick employees to take reasonable care to ensure that they and their colleagues worked in a safe environment and help Patrick achieve its obligations with regard to the OH&S risk management objectives required by the OH&S Act and regulation. This included following safe practices taught during training, following SWIs and providing feedback regarding observed practices in the workplace or SWIs or training which may not have been suitable for tasks being undertaken.

2.6.3 Patrick's safety system

To enable Patrick to fulfil its obligations under the OH&S Act and regulation, the company had implemented a safety management system (SMS) software package, known as a 'Safety Accountability Program'. This SMS was made up of 13 elements, namely: site survey improvement surveys; risk assessments (including hazard ID questionnaires); safe work instructions (developed from the risk assessments); accident/incident investigation; OH&S committee and communications; managing contractors; induction (including training and assessment); emergency and security; environmental management; safety related training and injury management. These elements helped Patrick comply with the company's statutory OH&S obligations.

SMS implications

Any SMS is intended to act as a framework to allow an organisation, as a minimum, to meet its legal obligations under OH&S legislation. Generally, the structure of an SMS is itself not a legal requirement but it is an extremely effective tool to organise the many aspects of OH&S that can exist within an organisation, often to meet standards which exceed the minimum legal requirement.

However, an SMS is only as good as its implementation. Effective safety management means that organisations need to ensure they are looking at all the risks within the organisation as a single system, rather than having multiple, competing safety management ‘silos’³². If safety is not seen holistically, it can interfere with the prioritisation of improvements or even result in safety issues being missed.

A truly safe operation is not defined simply by the presence of a good SMS³³. However, by having a good, effective SMS in place, an organisation is very well placed to be able to properly manage safety within the workplace.

According to Transport Canada, in their publication *Introduction to Safety Management Systems*³⁴:

As with all management systems, [an] SMS provides for goal setting, planning, and measuring performance. A proper SMS is woven into the fabric of an organisation so that it becomes part of the culture, i.e. the way people do their jobs.

Defences provided by a SMS

According to the International Chamber of Shipping/International Shipping Federation’s ‘*Guidelines to the application of the IMO International Safety Management (ISM) Code*’³⁵:

Accidents and pollution incidents do not just happen – they are caused, usually by more than one factor coming together at a particular place and time. Change any one of these factors, even slightly, and the accident would probably not occur. Instead one would experience what is termed a ‘hazardous occurrence’ or a ‘near miss’ – in other words a ‘near accident’.

An effective SMS relies on multiple barriers to protect against an accident. Unfortunately barriers may contain or develop unknown or unforeseen failures The multiple barriers in a good SMS will prevent accidents because a risk that is not stopped due to a failure in one barrier will be blocked by the next barrier. However, if failures in all the barriers coincide ... a clear path is open to the hazard, making an accident much more probable. The essential purpose of an effective SMS is to prevent failures in the barriers coinciding.

These barriers (defences) usually consist of employee attitudes, policies, training, procedures, hazard identification and risk assessment and control processes. While it may be virtually impossible to have an SMS where every defence is ‘hole free’ (i.e. an ideal SMS), organisations should endeavour to reduce the number of holes in these defences so as to minimise the chance of the holes becoming aligned, thus ensuring that every defence and the overall SMS is as effective as possible.

The elements in Patrick’s SMS were the organisation’s defences against an accident in the terminal or on board a ship berthed at the terminal. However, there were deficiencies in these defences, and this meant that there were ‘holes’ in the system

³² Evans, A. & Parker, J. *Beyond Safety Management Systems*, in Aero Safety World, May 2008.

³³ Evans, A. & Parker, J. *Beyond Safety Management Systems*, in Aero Safety World, May 2008.

³⁴ Transport Canada, publication TP 13739 (04/2001).

³⁵ 4th edition, 2010, page 12.

that on 28 March 2010 allowed seemingly unrelated events, or acts, to have an impact on one another. Consequently, the safety system was not as effective in enhancing safety at the Port Botany terminal as it could have been and consequently, the company's OH&S risk management framework was deficient.

The deficiencies in Patrick's safety system in place at the time of the accident on board *Vega Gotland* are looked at in more detail in the following sections.

2.6.4 Safe work instructions

Operational procedures, or in Patrick's case SWIs, are an important defence within a safety system which provide guidance to employees in the correct and safe way to carry out a task. Operational procedures, working hand-in-hand with personnel training (importantly reinforcing the contents of that training), play a critical role in the management of safety in the workplace.

At the time of the accident, Patrick's lashing and unlashings operation SWIs³⁶ gave stevedoring personnel basic safety guidance and covered generic steps associated with the task. This included assembling personal protective equipment, travelling to the ship, embarking the ship using the gangway, collecting and inspecting the lashing tools, surveying the working area, using the lashing equipment and clearing the walkways and decks after work was completed.

The SWIs did not specifically contain any guidance on, or warnings in relation to, working around containers which were being loaded or discharged, or working under a suspended/moving container (working under the hook). The only mention in the SWIs of portainer movements was in the step associated with locating the lashing rods and turnbuckles at the bay to be lashed and to 'maintain awareness of other operations in the area and cranes passing overhead'.

The seven trainee lashers working on board *Vega Gotland* on 28 March had all started work with Patrick in November 2009. Therefore, they had undertaken their induction training only a couple of months before the accident. The training had included the recognised safe practices of not working, standing or walking under or in the path of a suspended container or load (working under the hook), to 'never stand between a fixed object, such as cargo stack, and the likely path/swing of the load' and to 'always ensure that in the event of sudden load/spreader swing you have a clear area behind you'. When interviewed by ATSB investigators, the lashers stated that it was 'drummed' into them just how important these safety practices were.

However, the SWI did not re-state and therefore reinforce these recognised safe practices for lashing and unlashings operations. Consequently, a discontinuity existed between the training that the lashers underwent and the instructions designed to help the lashers safely carry out their tasks on board a ship.

The responsible officer for the SWIs was the Terminal Operations Manager. The responsible officer for the training materials was the National Training Manager. It is therefore possible that the lack of continuity between the stevedore training and the SWIs concerning the recognised safety practices may have been the result of the separation of responsibility between the two managers.

³⁶ Patrick document SSS0503, issued in October 2009.

In submission, Patrick stated that:

To further enhance the existing safety information provided regarding the hazards [of working near containers being handled], following the incident on 28 March 2010, the relevant SWIs were reviewed (in consultation with employees)...

Further to the initial training provided to employees on the RZP, the Terminal has also recently held refresher training for all employees in respect of the revised lashing/unlashing SWI. This SWI makes reference to the obligations and requirements in adhering to the RZP.

In support of this, Patrick provided the revised SWIs for the ship (deck) team leader and lashing/unlashing operations to the ATSB.

These SWIs are more comprehensive and detailed in their guidance than the documents which were in place at the time of the accident. Representatives from Patrick's management, safety, stevedoring and training teams contributed to the revision of the SWIs. The documents contain reference to the risks of being crushed between two containers and of being struck by something falling from a container and, as stated by Patrick, do contain extensive reference to adhering to the RZP. The SWIs also contain a new section detailing the responsibilities of the stevedores and managers in undertaking the task covered by the SWIs, including the need to communicate with shift managers/team leaders and report any deficiencies or breaches of the SWI and directing all staff to comply with the SWI.

As a result, the revised SWIs have removed the discontinuity that existed before the accident and now reinforce the recognised safe practices for lashing and unlashing operations which are taught during induction training.

Complying with safe work instructions

During the course of the ATSB investigation, it became evident that, despite training and the limited safety guidance provided in SWIs, some stevedores at the Patrick Port Botany terminal worked in such a way that some of their actions constituted 'unsafe acts' that placed them in a position of danger if something unexpected were to happen.

Some of these unsafe work practices included working under or near containers being handled, lashing containers which had just been loaded while others were being loaded next to them, and lashing containers while the portainer spreader was still connected to the container where there was a risk of the container moving. By working in this way, the stevedores were not following recognised safe work practices or Patrick training and guidance and were putting themselves at risk.

Workplace health and safety training and safety procedures/guidelines are 'good rules' and can only be effective in enhancing safety in any workplace if the instructions/guidance delivered during the training, or contained in the procedures/guidelines, is followed.

Safe operating procedures are written to shape people's behaviour so as to minimise accidents. As such, they form part of the system defences against accidents.³⁷

³⁷ Lowle, M. *The Human Element – Errors and violations*, as contained in the UK P&I Club Loss Prevention News, September 2003, Issue 16, pages 11 to 14.

Assuming that a safe operating procedure is well founded, any deviation will bring the violator into an area of increased risk and danger. The violation itself may not be damaging but the act of violating takes the violator into regions in which subsequent errors are much more likely to have bad outcomes. This relationship can be summarised:

Violations + errors = injury, death and damage.³⁸

Violations at the skill-based level

In the workplace, people operate on three levels of performance:

- Skill-based, in which individuals carry out routine, highly-practised tasks, in a largely automatic way where there is little conscious thought, except for occasional checks on progress.
- Rule-based, where the individual needs to modify their largely pre-programmed behaviour in line with some change in the situation around them. They face a task which is one they have encountered before, or have been trained for, or which is covered by written procedures. At this level, the individual must apply some conscious thought.
- Knowledge-based, which requires the individual to use a large amount of conscious thought to come up with a solution to an unfamiliar task.

Stevedores, while working on board container ships, probably work predominantly at the skill-based level. At the skill-based level, safe work procedures or instructions have to be fairly general in nature. This can mean that they are open to different interpretation by those who use them, depending on how closely a person wants to follow them, and can lead to violations of the procedures. If the initial violations are not identified, then they can become the routine way that the task is done.

These 'routine violations' can be characterised by the phrases 'this is how we have always done it and nobody has been hurt' or 'we do it like this all the time and nobody notices'. Routine violations are almost invisible until there is an accident or an audit identifies the fact that violations are occurring.

According to James Reason³⁹:

These violations form part of a person's repertoire of skilled or habitual actions. They often involve corner-cutting (following the path of least effort between two task-related points). Such *routine violations* are promoted by inelegant procedures and a relatively indifferent environment. That is, one that rarely punishes violations or rewards compliance.

In general, there is very little need to proceduralise activities at the skill-based level. For the most part, actions are governed by stored habits or actions whose details are, in any case, beyond verbal control or even recall. There is no point, for example, in writing procedures to tell a skilled tradesperson how to use a screwdriver. Where procedures do cover activities at the skill-based level, they tend to take the form of general exhortations (e.g. proceed with due caution...

³⁸ *ibid.*

³⁹ Reason, J. *The Human Contribution – unsafe acts, accidents and heroic recoveries*. Ashgate, England, 2008, pages 51-52.

care should be taken when...).

Widespread routine violations are generally indicative of a problem at an organisational level, rather than the result of one individual's actions in the workplace. Routine violations become established in a workplace when there is a lack of oversight of, or intervention by management in unsafe practices by employees. If management are aware of, but do not take action against routine violations, they will continue to occur within the workplace with an implicit 'approval' from management.

The unsafe work practices followed by some of Patrick's stevedores resulted in the violation of several SWIs and recognised safe working practices. These routine violations had not been identified and remedied by Patrick management.

2.6.5 Safe work instructions compliance auditing and review

A core operational activity of a safety system is safety assurance (safety performance monitoring and measurement, the management of change and continuous improvement of the safety system).

According to the International Civil Aviation Organization's (ICAO) safety management manual⁴⁰:

...safety assurance must be considered as a continuous, ongoing activity aimed at a) ensuring that the initial identification of hazards and assumptions in relation to the assessment of the consequences of safety risks, and the defences that exist in the system as a means of control, remain valid and applicable as the system evolves over time; and/or b) introducing changes in the defences as necessary.

Therefore, an effective safety system should have a review and continuous improvement process in place to ensure that operations are being conducted in accordance with procedures and that the procedures themselves properly reflect the way operations are carried out in the workplace. If they do not, then one or the other, or both, need to be changed.

Despite having SWIs aimed at reducing the risk of an accident, and an extensive training regime for new employees, at the time of the accident Patrick did not have any process in place, such as compliance auditing, to ensure that its stevedores were following the training they had received and the guidance contained in the SWIs.

It is likely that the unsafe work practices, or routine violations of the SWIs, were the result of many years following the same or similar practices where there were few or no safe operating procedures/instructions and a lack of processes in place to monitor compliance with policies, procedures and training.

It was not uncommon for new employees, after they had finished their induction training, to be exposed to these unsafe work practices during the on-the-job experience phase of their training.

It is a human tendency to take the path of least effort⁴¹. Consequently, in the absence of any proper monitoring for compliance with the company's SWIs, it was

⁴⁰ Chapter 8 (SMS planning)), Safety Management Manual (SMM). Doc 9859, International Civil Aviation Organization (ICAO), page 8-1 and 8-2.

easier for the new Patrick employees to follow the unsafe practices, and therefore fit into the normal working practice of their colleagues, and not the safe work practices that they had been taught 'in the classroom'. As a result, it appears that the lack of compliance auditing had led to a cycle of non-compliance becoming even more entrenched and self-perpetuating in the terminal.

In submission, Patrick stated that:

Patrick did have a system in place to ensure that SWIs and policies were followed during container operations. This system comprised:

- comprehensive induction training;
- induction assessments;
- provision of training to employees in the systems of work relevant to their roles;
- provision of supervision to those employees whilst conducting the work; and
- provision of comprehensive training to those providing the supervision (i.e. team leaders).

Team leaders were trained to (including but not limited to):

- ensure that all team members follow approved safe work instructions;
- advise employees of correct procedures in cases where safety rules are being ignored;
- ensure that team members understand the hazards associated with their work activities;
- ensure that the work area is safe to enter and work in;
- report all incidents including near misses to their Shift Manager;
- report all safety incidents in accordance with company policies.

The [Employee] Handbook also identified the required standards for employees including to:

- take care for their own and others safety;
- cooperate with the employer to enable safety compliance;
- maintain safe work practices at all times;
- report all hazards, incidents and accidents immediately.

To further support these required standards, employees were (and are) also informed and trained in a number of mechanisms and systems in place for the reporting of incidents at the Terminal including:

- a hazard report system;
- reporting to the Shift Manager in the form of a incident/near miss report;
- raising issues with the OHS committee as an agenda item through the OHS chairperson or members of the committee;
- verbal or written communication to any member of the management team.

These systems are identified and encouraged through the induction process and contained in the Handbook.

⁴¹ Reason, J. *Human error*. Cambridge University Press, 1990, page 196.

While it is clear that Patrick's safety system was focused on training and supervision, the missing link was the lack of an adequate system of compliance monitoring at the time of the accident. As a result, unsafe acts were seen to be undertaken by senior stevedores and this situation was not identified, and therefore not rectified, by management. Therefore, the SWI review process was not as effective as it could have been.

Use of mobile phones

The use of mobile telephones in today's society is convenient, pervasive and, in some cases, important for the efficient operation of businesses. However, using a mobile telephone can be a distraction and their use in many workplaces can increase the risk of the user, or someone in close vicinity of the user, being involved in a workplace accident or incident, because their attention might not be on the task at hand.

With regard to the use of mobile telephones in the workplace, Patrick's mobile telephone policy stated⁴²:

The use of mobile phones and portable music devices in operational areas has been identified as a high-risk activity because they interfere with your ability to work safely. As a result, you are required to comply with the following at all times:

- mobile telephones for private use are banned in all operational areas, unless authorised in the site safety rules;
- company issued mobile telephones may be used in operational areas in compliance with any site guidelines for their use.

This policy was clear and unambiguous and new employees were made aware of the requirements during their induction training. Prospective team leaders were also reminded of this during their training.

However, during the ATSB investigation, it became evident that the use of mobile telephones by Patrick stevedores while on board ships was extensive. This was illustrated by the fact that, despite knowing that the policy banned mobile telephones in operational areas, at the time of the accident, the trainee lasher assisting the lashing team leader was talking on his personal mobile telephone.

Not only did the trainee lasher answer the telephone when it rang, his team leader permitted him to remain on the telephone during the lashing operation. This illustrates the degree of acceptance of non-compliance with Patrick's mobile telephone policy by stevedoring personnel and is indicative of the extent to which routine violations in this regard were occurring in the workplace.

While his actions did not directly contribute to the accident, the trainee lasher's attention was diverted while he was using the mobile telephone and so his ability to look out for the safety of his fellow stevedores, or indeed his own, was compromised.

With regard to the non-adherence to company policies and SWIs, Patrick stated in their submission that:

To further promote and reinforce these required [safety] standards, Patrick has

⁴² Patrick Terminals 2008 Employee Handbook – Policies, Entitlements and Obligations.

implemented a process of safety observations, whereby its supervisors participate in observing and discussing 'on the job' safety with employees and contractors relative to the tasks being carried out. The intent of the safety observation (also known as a 'safety conversation') process is to encourage two-way communication between supervisors and employees regarding safety and ways to enhance safety at Patrick sites. The safety observation process is a consolidation of existing supervision and consultation processes.

2.6.6 Hazard identification and risk assessment

Aside from safety assurance, another core operational activity of a safety system (and a requirement under the NSW OH&S Act and regulation) is safety risk management (hazard identification and risk assessment and mitigation). According to ICAO's safety management manual, 'safety risk management must be ... aimed at initial identification of hazards in the context in which operations related to the delivery of services will take place⁴³'.

Therefore, it is necessary for a company to have an effective process in place to identify hazards and an accompanying process of assessing the risk and developing risk controls. Together, these play an important part in managing safety in the workplace and in minimising the chance of any holes in defences becoming aligned.

Hazard identification

In addition to SWIs, Patrick had undertaken assessments of the hazards involved in the numerous operational tasks involved in the loading and discharge of ships at its terminals. A hazard identification questionnaire for lashing and unlashings (TT0802) was effective from 15 October 2009 and was due for review in October 2010.

The first page of the hazard identification questionnaire was linked to the lashing/unlashing SWI. It listed associated hazards identified for those steps in the SWI. The hazards identified were mainly associated with slips, trips, falls, strains, falling equipment and drops from height. There was no hazard identified associated with working 'under the hook' or working/standing between a moving and a fixed object.

These were known and foreseeable hazards, which were brought to the attention of employees during Patrick's training. However, they were not reflected in the documented hazard identification questionnaire, and consequently, Patrick did not introduce strategies to minimise the exposure of its stevedores to these hazards.

Risk assessment and controls

Despite the hazards mentioned above not being directly identified in the hazard identification questionnaire, the risk assessment template part of the questionnaire identified two hazards associated with being hit by 'something'. The first was in relation to items falling from a portainer or cargo and employees being struck by moving containers. The second described the hazard of being struck by twistlocks or lashing rods, and/or moving containers.

⁴³ Chapter 8 (SMS planning)), Safety Management Manual (SMM). Doc 9859, International Civil Aviation Organization (ICAO), page 8-1 and 8-2.

For each of these items, a risk assessment was undertaken and controls recommended to manage those risks. The severity of an employee coming into contact with the hazards ranged from a near miss to an employee being absent from work (from 3 days to 3 weeks) but achieving a complete recovery.

However, the foreseeable risk of a fatal accident resulting from being struck by items falling from a portainer or cargo, or from being struck by a moving container, was not anticipated during the risk assessment process connected with lashing and unlashings operations. As a result, while the appropriate risk control for this occurrence had been covered during employee training, the importance of someone not putting themselves in a position where this occurrence could happen was not reinforced in the SWIs, an important risk control measure.

In submission, Patrick stated that:

Subsequent to the initial implementation of the RZP, risk assessments were reviewed and further risk assessments conducted. This was done in consultation with operational employees at various levels and occupying differing roles including members of the OHS committee.

These revised hazard and risk assessment/control documents were provided to the ATSB by Patrick during the investigation. They show that more holistic hazard and risk assessments were conducted regarding lashing and unlashings tasks with the 'restricted zone' in place. These assessments/controls included instructions that no lashing operations are to take place within the confines of the restricted zone and made reference to the duties of the deck team leader in his/her responsibility for control of the restricted zone, the implementation of the observation program to monitor compliance with the RZP, training for all lashers in the RZP and the incorporation of the RZP into the lasher induction training program.

In addition to the responsibility for the deck team leader to implement the RZP, the documents also provide for instructions to be given to all employees in the RZP before commencing any lashing task and gives responsibility to the shift manager to monitor the observance of the RZP by planning safe work observations of the RZPs on a random basis.

2.6.7 Reporting risk-related events

Reporting of risk-related events is fundamental to any effective safety system. These events include what are commonly known as near misses, non-conformities, unsafe acts, risk events, incidents, accidents and hazardous occurrences. Reporting risk-related events is a proactive strategy because it can initiate remedial action to prevent a serious incident. The reaction to incidents usually involves addressing safety issues that could have been identified earlier from near misses. This means that the reporting of risk-related events provides an opportunity to identify the underlying risks which, if left unattended, can result in a serious incident.

With regard to proactive reporting, Hopkins⁴⁴ states:

A reporting culture

Above all else, a safety culture is a reporting culture, in which people are prepared

⁴⁴ Hopkins, A. *Safety, culture and risk – the organisational causes of disasters*. CCH Australia. 2005, page 12.

to report errors, near misses, unsafe conditions, inappropriate procedures and any other concerns they may have about safety. The issue is not whether the organisation has a reporting system; it is whether, as a matter of practice, such things are reported. This will happen only if people are on the lookout for things which need to be reported and alert to the ways in which things may be going wrong.

A just culture

A reporting culture depends in turn on how the organisation handles blame and punishment. If blame is the routine response to error, then reports will not be forthcoming. If on the other hand, blame is reserved for behaviour involving defiance, recklessness or malice, reporting in general will not be discouraged. What is required is not so much a no-blame culture as a just culture.

It is well known that people are not likely to report any risk-related event if they think that they will be punished or disadvantaged for reporting the event/s. It is also necessary for people to feel that they are part of an organisation that learns from near misses, mistakes and incidents. In such a 'learning culture', people are not likely to become disillusioned and not report because of their organisation's inaction (perceived or otherwise) or because reports are being ignored. These concepts of culture are the sum of the collective values, attitudes and behaviours of the management and individuals within an organisation.

Therefore, an effective safety system is heavily reliant on a reporting culture and closely related organisational characteristics. It is important that individuals believe they are working to reduce risk within their organisation so that all opportunities to reduce risk are taken. Given the potentially severe consequences of a serious incident in the stevedoring industry, near miss reporting is critical. Proactive reporting by stevedores provides ideal opportunities to identify and reduce risk in the workplace to a level as low as reasonably practicable (ALARP) and it is required of them under Section 20 of the OH&S Act.

While Patricks had a system in place for its employees to report the risk-related events observed in the terminal, the 270 'hazard/fault' reports received by Patrick Port Botany terminal management in the 24 months before the accident on board *Vega Gotland* were predominantly concerned with fault reporting connected with terminal equipment or machinery. All 270 reports were submitted by stevedores working in the terminal, driving the straddle carriers or driving the portainers. There were no reports from any stevedore working on a ship berthed alongside.

In addition to these 270 'hazard/fault' reports, in the same period, 62 incident reports were submitted to the Port Botany terminal management. Like the 'hazard/fault' reports, these incident reports concerned occurrences associated with the operation of terminal equipment.

Of all the 'hazard/fault' and incident reports, none concerned;

- an unsafe act on the part of a stevedore,
- a 'near miss' as a result of an unsafe act,
- a non-compliance with company SWIs/ policies, or,
- the inappropriateness of the SWIs or policies.

Therefore, the practice of reporting non-compliances or unsafe acts does not appear to have been encouraged by Patrick management. This, combined with the fact that Patrick management did not have a compliance auditing process in place, meant that management were probably unaware of the extent to which the SWIs were not being followed.

The comradeship between stevedores in Australia is a particularly strong one. It is possible that the stevedores did not submit risk-related event reports because they thought that making a report might result in action being taken against one of their colleagues. Consequently, two critical parts of an effective safety system, which had a direct impact upon its ability to effectively manage safety in the terminal, the 'reporting' culture and the 'just' culture, were either not present or were misunderstood in Patrick's safety system.

2.7 Patrick accident notification and investigation

At the time of the accident, Patrick had a procedure for incident reporting and investigation (TO0802). The procedure contained a number of requirements that needed to be completed in the event of a 'category 1 accident', a fatality. These were:

- the completion of an incident report,
- the completion of a lashing injury checklist (if necessary),
- a list of any interim controls implemented,
- a list of anything done by employees following the accident,
- inclusion of any correspondence with the company legal representatives,
- completion of the accident analysis and improvement checklist, and
- the inclusion of any minutes of occupational health and safety (OHS) meetings, noting that this type of occurrence must go on the agenda for the terminal's OHS committee.

In the 24 months before the accident on board *Vega Gotland*, 62 incidents were reported to Patrick Port Botany terminal management by stevedores. The incidents involved a variety of occurrence types and each incident was investigated by Patrick management. The corrective action taken by Patrick depended on the severity of the occurrence.

During the investigation of the accident onboard *Vega Gotland*, the ATSB requested copies of the above which should have been completed after the accident.

While the ATSB was advised by Patrick that safety action had been taken immediately following the accident, 'in relation to this particular incident, a decision was made by Patrick management not to create such documents in accordance with its internal procedures, as is within its discretion to do so on a case by case basis'.

In submission, Patrick stated that:

Following the incident, Patrick acted quickly in reviewing the relevant SWIs in consultation with employees and implemented the 'restricted zone protocol'. All relevant personnel were trained in the 'restricted zone protocol' prior to re-commencing work. Further, employees and management participated in safety

observations specific to assessing adherence to the ‘restricted zone protocol’.

The action taken by Patrick did not jeopardise safety at the site nor did it limit Patrick's capacity for further learning and enhancement opportunities in any way. Further, this did not prevent the Terminal from taking appropriate action where necessary.

Patrick has, in consultation with its workforce, continued to review, re-assess and refresh protocols, training and relevant SWIs if necessary and where appropriate, to enhance safety at the Terminal.

Despite this action taken by Patrick, the ATSB believes that, by not following the investigatory guidance provided in the procedure, the process undertaken might not have been as effective and as transparent as it could have been. Consequently, there could have still been some opportunities for Patrick and its stevedores to learn from the accident so as to reduce the risk of something similar happening in the future. However, the ATSB does acknowledge that substantial safety action was taken by Patrick immediately following the accident.

2.8 Guidance available for stevedoring operations

The stevedoring industry can be hazardous and the risks to personnel need to be properly managed. In order to help to reduce the risks of accidents on the waterfront, guidance is available, at both the national and international levels, to assist stevedoring operators develop appropriate safe work procedures and instructions.

2.8.1 International guidance

To help combat the accident rate, internationally, organisations like the International Labour Organization (ILO) and the International Cargo Handling Coordination Association (ICHCA International) have published codes of safe working practices, briefing papers/pamphlets and guidance manuals to help national administrations and stevedoring employers develop their own guidance material and SMS contents.

ICHCA International has published *Container Terminal Safety* and *Safe Working on Container Ships*. In this publication, there is discussion regarding issues such as safe access to ships and working on container tops. However, the only mention of working between a container being loaded and a fixed object is in the introduction, where it states:

1.1 This pamphlet is written as a general guidance for use in connection with stevedoring operations on container ships. It is recommended that it should form the basis of operational procedures for all terminals.

1.2 The majority of accidents to dock workers on container ships occur during lashing and unlashings operations due to falling objects, openings in decks or inadequate walkways. The most serious accidents are either due to falls from container tops or crushing injuries during the lowering of containers.

In the ILO code of practice *Health and Safety in Ports*, under the section on container ship operations, no mention is made of working between a moving container and a fixed object. The reader is referred to obtain further general

guidance on safe work on container ships from the ICHCA International Safety Panel Briefing Pamphlet No. 8 - *Safe working on container ships*.

The other main ILO code of practice is *Accident Prevention on board Ship at Sea and in Port*. Section 24.3 deals with container ships. Like the other ILO code above, there is no mention of the dangers associated with standing between moving containers and stationary objects.

Despite ICHCA International identifying that ‘the most serious accidents are either due to falls from containers or crushing injuries due to the lowering of containers’, no further guidance is provided in that document, or the ILO codes of practice, for terminal operators with regard to reducing the risk of crushing injuries during the lowering of containers, including the risk of being crushed between two containers.

2.8.2 Australian guidance

At the time of the accident, there were no national workplace health and safety regulations or codes of practice (although work had started on one) which specifically covered stevedoring operations in Australian ports.

In October 2009, Safe Work Australia⁴⁵, working in collaboration with the Maritime Union of Australia (MUA), the Australian Maritime Safety Authority (AMSA), shipping agents and stevedoring companies, adapted several WorkSafe Victoria publications, developed for use in Victorian ports, for use nationally. All these guides state that they should be read in conjunction with AMSA’s *Marine Orders Part 32* (Cargo Handling Equipment) and the ILO’s Code of practice on *Health and Safety in Ports*.

At the time of the accident on board *Vega Gotland*, these guides were the closest thing to an industry code of practice available in Australia.

One of these guides, *Working safely with containers* (and its associated checklist), focused specifically on the handling of containers at terminal operations and provided a range of options to address identified risks. It set out what compliance could look like for a range of issues identified by stakeholders.

This guide contained a large number of ‘comparative charts’. These charts ‘provide summaries of identified hazards and assessments of the risks associated with particular stevedoring work practices’. Charts covered the shipboard working environment, communications, equipment, and personnel.

In the shipboard work environment chart, ‘working directly under loads being lifted or lowered or under path of travel, or in vicinity of path of travel’ was identified as a high risk. However, like the international guidance, the dangers associated with working between a moving container and a fixed object were not identified or mentioned.

⁴⁵ An Australian Government statutory agency established in 2009, with the primary responsibility of improving work health and safety and workers’ compensation arrangements across Australia. The agency took over the responsibilities of the Australian Safety and Compensation Council, which was disbanded in March 2009.

2.8.3 Future Australian guidance

In 2010, Safe Work Australia established a Stevedoring Temporary Advisory Group (TAG) to look at the issue of safety in the Australian stevedoring industry. The scope⁴⁶ of the TAG was to build on work commenced by the Australian Safety and Compensation Council by considering safety issues facing stevedores on the Australian waterfront and to evaluate the need for further regulatory or guidance material.

Put simply, the role of the TAG was to identify the risks posed to workers in the Australian stevedoring industry and then to decide on how best to manage those risks to make the Australian waterfront a safer place to work.

Members of the TAG consisted of representatives from industry stakeholders (including employers and the MUA), federal and state maritime and safety jurisdictions (including AMSA and Safe Work Australia), and subject matter experts.

The following safety related matters were to be considered by the TAG⁴⁷:

- What are the specific safety issues facing stevedores on the Australian waterfront?
 - Are these issues unique to the stevedoring industry or are similar issues occurring in other sectors?
- How effective have existing state and territory OHS legislative frameworks and compliance activities been in regulating safety in the stevedoring industry?
 - Are there any issues likely to arise from the interaction of the model Work Health and Safety legislation and Marine Order 32 that need to be addressed?
- How effective is the guidance material published by Safe Work Australia in October 2009 in improving safety outcomes for stevedores?
 - Does the guidance material cover the safety issues identified?
 - Is the existing guidance set out in the material, if followed, sufficient to address the issues identified and improve safety outcomes in the future?
 - Can this guidance material be improved?
 - What has been the industry up-take of the existing guidance material?
- Is additional material (e.g. guidance material, codes of practice or regulations) required to address identified safety issues?
 - If so, what specific safety issues need to be addressed and what are the details of the safety requirements needed to address them?
- Are there international developments in this field that can assist in the development of Australia's approach to safety in the stevedoring industry?

At the time this report was published, the TAG was continuing to meet to consider safety issues facing stevedores on the Australian waterfront and to evaluate the need for further regulatory or guidance material.

⁴⁶ As contained in Agenda Item 1 of the Safe Work Australia Stevedoring Temporary Advisory Group meeting, September 2010.

⁴⁷ As contained in Agenda Item 1 of the Safe Work Australia Stevedoring Temporary Advisory Group meeting, September 2010.

In submission, Patrick stated that:

To further enhance its safety culture ... Patrick continues to participate in and take an active role on the Stevedoring TAG working with other stevedoring industry representatives in an effort to achieve consistent industry safety standards and to enhance its own safety journey.

3.1 Context

At about 1918 on 28 March 2010, the stevedore lashing team leader working on board the container ship *Vega Gotland* was crushed between two containers during loading operations. The team leader died instantly from the injuries he received in the accident.

From the evidence available, the following findings are made with respect to the stevedore fatality on board *Vega Gotland* and should not be read as apportioning blame or liability to any particular organisation or individual.

3.2 Contributing safety factors

- On the evening of 28 March 2010, the lashing team leader had agreed to lock the after manual twistlocks after containers were loaded in Bay 20. In doing so, he had positioned himself where he was exposed to the risk of being trapped between a container which was being positioned and a container which had been loaded earlier.
- It is probable that the lashing team leader had become desensitised to the risks associated with loading and lashing containers and this resulted in him placing himself in a position of danger at the after end of the container being loaded.
- The spacing between *Vega Gotland*'s containers required each container to be manoeuvred into position, usually by locking the forward twistlocks and lifting the container slightly to align with the after twistlocks.
- Manual twistlocks were used to secure the bottom tier of containers to the ship's hatch covers. Consequently, a stevedore was required to be in proximity of container loading operations to lock the twistlocks.
- The portainer driver did not know that the lashing team leader would be locking the after twistlocks when the containers were loaded in Bay 20 deck and hence did not look out for the lashing team leader while he was positioning the containers.
- *Vega Gotland*'s crew had not properly secured the hatch cover, on which the container was being loaded, to the hatch coaming. Consequently, when the portainer lifted the container to reposition it, the hatch cover lifted as well which resulted in the failure of the twistlock foundation.
- The failure of *Vega Gotland*'s twistlock foundation assembly was consistent with its exposure to gross overstress conditions as a result of the leverage forces applied to it by the container and the unsecured hatch cover and this contributed significantly in the failure of the welds.
- Patrick Terminals had no formalised policy in place to provide clear guidance to its stevedoring employees about where they should or should not work on a ship when cargo was being loaded or discharged. *[Significant safety issue]*
- The implementation of Patrick Terminal's safety management system resulted in an environment where Patrick Terminal management and stevedores were disconnected in relation to the management of some of the day-to-day

workplace safety risks. As a result, there was little ownership of the safe work instructions by the stevedores, and some of the more experienced stevedores were probably no longer aware of the risks posed to them when they undertook unsafe 'workarounds' in the workplace and these were not identified by Patrick management. *[Significant safety issue]*

- Patrick Terminals' safe work instructions for lashing/unlashing did not specifically cover the recognised safe practices of not working under containers or between moving containers and fixed objects. Consequently, there was a discontinuity between the level of awareness regarding these dangers and the training new employees received during their induction period. *[Significant safety issue]*
- Patrick Terminals' hazard identification process had not identified the dangers of working near or under containers being loaded. *[Significant safety issue]*
- Patrick Terminals' risk assessment process for lashing and unlashing operations had not anticipated a fatal accident resulting from being struck by items falling from a portainer or cargo, or from being struck by a moving container. As a result, while the appropriate risk control for this occurrence had been covered during employee training, this was not reinforced in safe work instructions, an important risk control measure. *[Significant safety issue]*

3.3 Other safety factors

- The culture which existed in the Patrick Terminal did not encourage the reporting of non-compliances or unsafe acts. Consequently, two critical parts of an effective safety system, which had a direct impact upon its ability to effectively manage safety in the terminal, the 'reporting' culture and the 'just' culture, were either not present or were misunderstood in Patrick's safety system. *[Significant safety issue]*
- The recognised safe practices of not working under or near a container being loaded is not well reflected in national and international guidance to assist container terminal operators develop their own safety policies and guidelines. *[Minor safety issue]*

The safety issues identified during this investigation are listed in the Findings and Safety Actions sections of this report. The Australian Transport Safety Bureau (ATSB) expects that all safety issues identified by the investigation should be addressed by the relevant organisation(s). In addressing those issues, the ATSB prefers to encourage relevant organisation(s) to proactively initiate safety action, rather than to issue formal safety recommendations or safety advisory notices.

All of the responsible organisations for the safety issues identified during this investigation were given a draft report and invited to provide submissions. As part of that process, each organisation was asked to communicate what safety actions, if any, they had carried out or were planning to carry out in relation to each safety issue relevant to their organisation.

4.1 Patrick Terminals

4.1.1 Safety zone guidance

Significant safety issue

Patrick Terminals had no formalised policy in place to provide clear guidance to its stevedoring employees about where they should or should not work on a ship when cargo was being loaded or discharged.

Action taken by Patrick Terminals

As discussed in section 2.5 in this report, the ATSB has been advised by Patrick Terminals that, following the accident on 28 March 2010, a restricted zone and associated restricted zone protocol (RZP) was implemented on 30 March 2010. The RZP restricts personnel access to the restricted zone whilst loading/unloading operations are taking place. The RZP is also communicated to the ship's crew.

The RZP consolidates the safety information already provided to all employees during induction and the information contained in various safe work instructions. All relevant personnel were trained in the RZP prior to re-commencing work after the accident. Further, employees and management participated in safety observations specifically to enable them to assess adherence to the RZP. In accordance with existing procedures and team leader requirements, team leaders are to reinforce and monitor adherence to the RZP by workers.

Patrick Terminals is in the process of further consultation with employees and Workcover NSW to determine further enhancements to the RZP. One such enhancement is the trialling of a barricade system.

ATSB assessment of the action

The ATSB is satisfied that the action taken by Patrick Terminals adequately addresses this safety issue.

4.1.2

Safety management

Significant safety issue

The implementation of Patrick Terminal's safety management system resulted in an environment where Patrick Terminal management and stevedores were disconnected in relation to the management of some of the day-to-day workplace safety risks. As a result, there was little ownership of the safe work instructions by the stevedores, and some of the more experienced stevedores were probably no longer aware of the risks posed to them when they undertook unsafe 'workarounds' in the workplace and these were not identified by Patrick management.

Response from Patrick Terminals

The ATSB has been advised by Patrick Terminals that although the company had a 13 element structured safety management system software package in place, as part of Patrick's continuous enhancement program the package was upgraded to a 15 element SMS to include 'quality' and 'leadership', with an increased focus on assessing the site against the SMS. This upgrade supports a more holistic approach to safety management at the Terminal in line with Patrick's broader safety initiatives and continuous enhancement strategy.

The upgraded safety management elements include: legal compliance and requirements; risk and change management; audit, inspection and review; communication, consultation and involvement; incident management; and performance measurement and customer review.

This upgrade is aligned to the recently implemented Patrick Safety, Health, Environmental and Quality Standards, which provide the framework for management systems and legislative compliance throughout the Patrick business. These standards define the performance standards expected within each business unit.

Additionally, in order to further promote and reinforce the required safety standards within the terminal and on board ships berthed at the terminal, Patrick has implemented a process of safety observations, whereby its supervisors participate in observing and discussing 'on the job' safety with employees and contractors relative to the tasks being carried out. The intent of the safety observation (also known as a 'safety conversation') process is to encourage two-way communication between supervisors and employees regarding safety and ways to enhance safety at Patrick sites. The safety observation process is a consolidation of existing supervision and consultation processes.

ATSB assessment of response

The ATSB is satisfied that the action taken by Patrick Terminals adequately addresses this safety issue.

4.1.3 Safe work instructions

Significant safety issue

Patrick Terminals' safe work instructions for lashing/unlashing did not specifically cover the recognised safe practices of not working under containers or between moving containers and fixed objects. Consequently, there was a discontinuity between the level of awareness regarding these dangers and the training new employees received during their induction period.

Action taken by Patrick Terminals

As discussed in section 2.6.4 of this report, the ATSB has been advised by Patrick Terminals that the safe work instructions for lashing/unlashing, and for the deck team leader, were extensively revised following the accident. Representatives from Patrick's management, safety, stevedoring and training teams were represented in the revision of the safe work instructions. These revised safe work instructions now cover the recognised safe practices of not working under containers or between moving containers and fixed objects and make extensive reference to adherence to the restricted zone protocol. As a result, the revised safe work instructions have removed the discontinuity that existed before the accident and now reinforce the previously mentioned recognised safe practices for lashing and unlashing operations which are taught during induction training.

ATSB assessment of the action

The ATSB is satisfied that the action taken by Patrick Terminals adequately addresses this safety issue.

4.1.4 Hazard identification

Significant safety issue

Patrick Terminals' hazard identification process had not identified the dangers of working near or under containers being loaded.

Action taken by Patrick Terminals

As discussed in section 2.6.6 of this report, the ATSB has been advised by Patrick Terminals that hazard identification and risk assessments for lashing/unlashing were revised following the accident and the implementation of the restricted zone protocol. This revision considered the hazards associated with working near containers being loaded and this was included in the revised hazard list. The implementation of the restricted zone protocol reduces the risk of stevedores working directly in the vicinity of containers being loaded or moving overhead.

ATSB assessment of the action

The ATSB is satisfied that the action taken by Patrick Terminals adequately addresses this safety issue.

4.1.5 Risk assessment and controls

Significant safety issue

Patrick Terminals' risk assessment process for lashing and unlashings operations had not anticipated a fatal accident resulting from being struck by items falling from a portainer or cargo, or from being struck by a moving container. As a result, while the appropriate risk control for this occurrence had been covered during employee training, this was not reinforced in safe work instructions, an important risk control measure.

Action taken by Patrick Terminals

As discussed in section 2.6.6 of this report, the ATSB has been advised by Patrick Terminals that hazard identification and risk assessments for lashing/unlashing were revised following the accident and the implementation of the restricted zone protocol. This revision considered the hazards associated with working near containers being loaded and this was included in the revised hazard list. The implementation of the restricted zone protocol reduces the risk of stevedores working directly in the vicinity of containers being loaded or moving overhead.

The revised safe work instructions for lashing/unlashing now reinforce the recognised safe practices of not working under a container or between a moving container and a stationary object.

ATSB assessment of the action

The ATSB is satisfied that the action taken by Patrick Terminals adequately addresses this safety issue.

4.1.6 Risk-related event reporting

Significant safety issue

The culture which existed in the Patrick Terminal did not encourage the reporting of non-compliances or unsafe acts. Consequently, two critical parts of an effective safety system, which had a direct impact upon its ability to effectively manage safety in the terminal, the 'reporting' culture and the 'just' culture, were either not present or were misunderstood in Patrick's safety system.

Response from Patrick Terminals

The ATSB has been advised by Patrick Terminals that the company has, in consultation with its workforce, continued to review, reassess and refresh protocols, training and relevant safe work instructions as necessary and where appropriate, to enhance safety at the Port Botany terminal. It is intended and anticipated by Patrick Terminals that the initiatives discussed earlier in its response to the ATSB draft report will further increase the focus and understanding by employees of the importance of accurate and regular incident/hazard/near-miss reporting to the provision and maintenance of a safe workplace for all persons; and encourage employee participation in investigations moving forward.

ATSB assessment of response

The ATSB is satisfied that these measures put forward by Patrick Terminals will, if properly persisted with over time, serve to address this safety issue.

4.1.7 Additional response from Patrick Terminals concerning safety actions taken following the accident on board *Vega Gotland*

The ATSB has been advised by Patrick Terminals that, following the accident:

To further enhance its safety culture, Patrick identified and took the opportunity to enhance its existing safety capabilities by employing additional experienced and qualified safety professionals to assist and support it in its safety journey across its sites.

In August 2010, Patrick launched the 'Home *Safely* Everyday' initiative and around the same time, launched its Safety Beliefs, Personal Safety Values and Safety Observations.

The Safety Beliefs include the following:

- Safety is a Management Responsibility (all levels of management);
- Involvement of all employees is essential;
- Working safely is a condition of employment.

Personal Safety Values include the following:

- Work safely and not knowingly endanger the safety and health of others;
- Comply with all workplace standards, procedures and directions;
- Report all injuries and incidents as soon as possible after they occur;
- Immediately stop another person from working unsafely;
- Report and take positive action on all hazards that I observe.

These initiatives were rolled out to employees by managers and supervisors at all Patrick sites and is supported by signage and posters.

Since the beginning of 2011, Patrick has rolled out its 'Safety Cardinal Rules' to all its sites. The 'Safety Cardinal Rules' are:

Violence and Bullying: Violence, horseplay, harassment or bullying is strictly prohibited.

Mobile Equipment: Local exclusion zones and procedures must be adhered to at all times. Only approach mobile equipment that is first stopped, from the side, at a safe distance and only after clear contact with the operator has been established.

Suspended loads: Working under a suspended load or lifting a load over any person is strictly prohibited.

Isolation: never interfere or use plant, equipment, facilities that have been tagged out, locked out or isolated.

Drugs and Alcohol: Being in possession of and/or under the influence of drugs or alcohol is strictly prohibited.

Restricted Areas: Unauthorised entry into areas that are restricted for operational safety reasons is strictly prohibited.

Working at Heights: Fall protection must be in place and utilised when working at heights.

As part of the 'Safety Cardinal Rules', Patrick has implemented its 'Workplace Safety Rules'. These include: mobile telephone usage; reporting injuries, incident and hazards; and adhering to SWIs and procedures. These rules serve as a reminder to employees of long standing existing site safety rules and required safety standards.

All these actions form part of Patrick's safety enhancement strategy with a focus on 3 key areas:

- Safe People;
- Safe Systems; and
- Safe Plant.

The process of continuous safety enhancement has formalised the safety observations process in addition to the existing processes of toolbox talks and 'on the job risk assessments' and further increased the focus and understanding of the importance of accurate and regular incident/hazard/near-miss reporting.

4.2 National and international maritime, cargo and labour organisations

4.2.1 National and international guidelines

Minor safety issue

The recognised safe practices of not working under or near a container being loaded is not well reflected in national and international guidance to assist container terminal operators develop their own safety policies and guidelines.

ATSB safety advisory notice MO-2010-002-SAN-031

The Australian Transport Safety Bureau advises that national and international maritime, cargo and labour organisations should consider the safety implications of this safety issue and take action where considered appropriate.

APPENDIX A: FAILURE ANALYSIS OF THE TWISTLOCK AND FOUNDATION

Introduction

On the evening of 28 March 2010, the top of a twistlock foundation unexpectedly separated from its base during the partial lifting of a 40 foot x 8 foot refrigerated container being loaded on board the container ship *Vega Gotland* (Figures A1a & b). At the time, the ship was trimmed about 2.5 m by the stern and the 29 tonne hatch cover onto which the container was being loaded was not properly secured to the hatch coaming, allowing it to lift when the attached container was lifted.

During the investigation, the ATSB took possession of the twistlock foundation top, and the manual twistlock which was still locked in it, from the WorkCover Authority of New South Wales. The foundation top was examined by ATSB technical investigators to determine how and why the MacGregor TF-11 twistlock foundation (i.e. top plate plus two side plates) failed. This appendix is the report of that examination.

Figure A1a & b: Twistlock assembly and top plate, as made fast to the container, and the two side plates, as made fast to the hatch cover.



Visual Examination

Apart from the tearing of the steel side plates from the top plate (Figures A1a & b), notable bending of the top plate occurred (Figure A2) where it made contact with the lower locking cone (Figure A1a) of the twistlock, thereby inducing reverse bending of adjacent sides (Figure A3a). As well, the lower cone indented the two undersides of the top plate (Figure A3b) where it had made contact.

When the twistlock was unlocked and removed from the foundation top, it was found that the lower cone had bent 4° with respect to the twistlock's central locking shaft, as compared with 2° for the upper cone (visible in the upper portion of Figure A4). The degree of lower cone bending can be readily seen in Figure A4 via the

inclination angle between the twistlock housing and the foundation top plate. Such bending reduced the clearance between the foundation top plate and twistlock housing on the port side to 4 mm (Figure A2) and increased it to 17 mm on the starboard side.

Figure A2: Port view of the assembly; note the 4 mm clearance (arrowed) and the curvature of the foundation top plate



Figure A3a & b: Deformed foundation top plate with two indentations on the underside (arrowed)

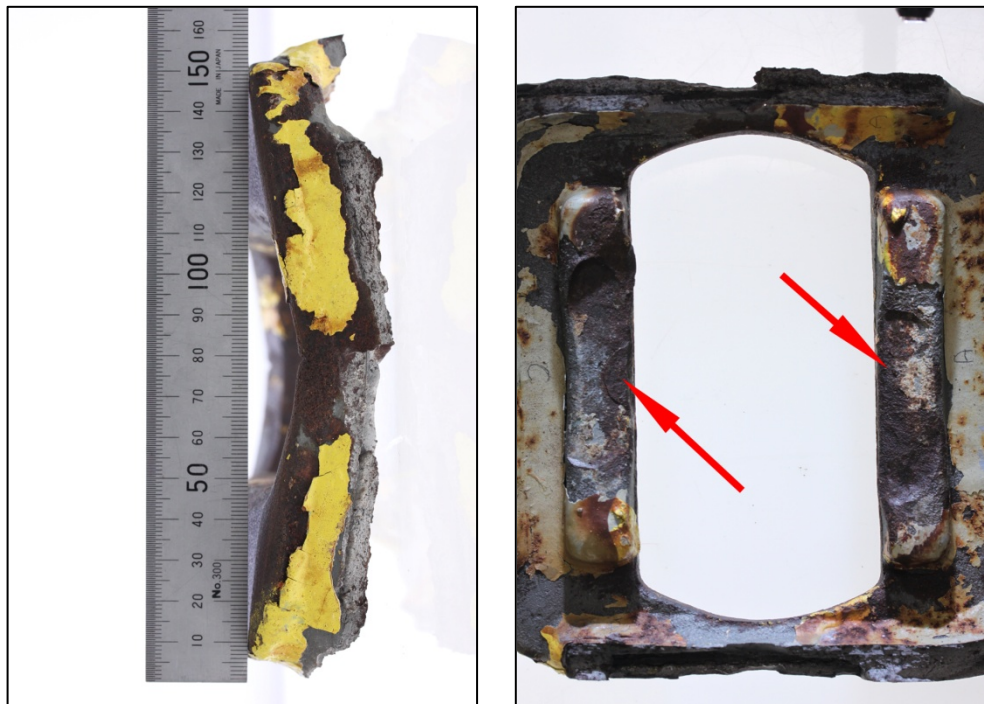
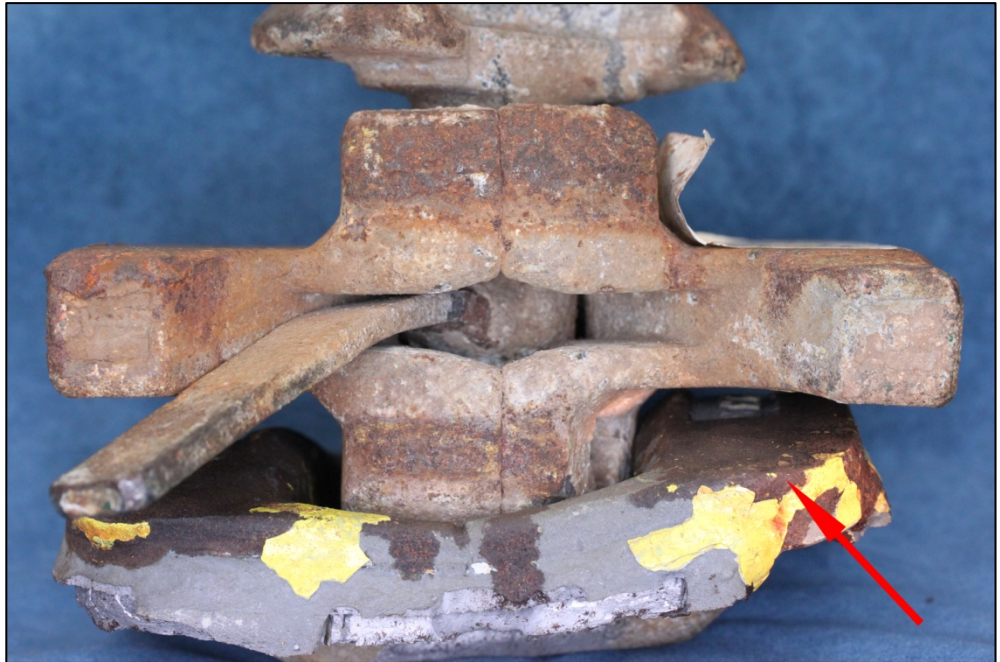


Figure A4: Forward view of the twistlock and top plate; note the angle between them, the bent upper cone plus the flattened facet on the port/forward corner of the foundation top (arrowed)



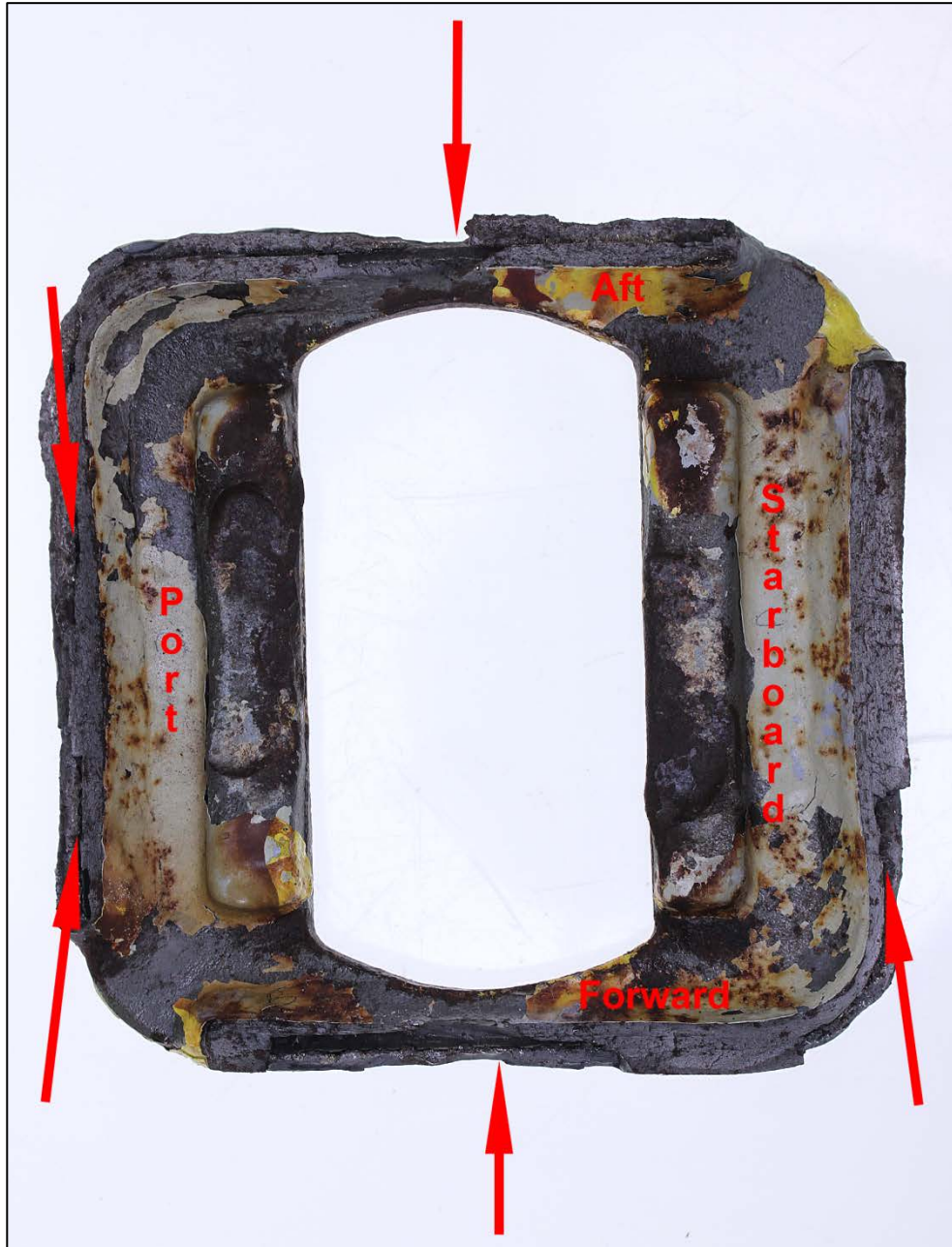
The flat facet indicated in Figure A4 was observed on the port/forward corner of the top plate (Figure A5a). A closer examination revealed that this witness mark also contained two rubbing marks, due to contact with the underside of the twistlock body (Figure A5b).

Figure A5a & b: Flat (arrowed) on the port/forward corner of the top plate and witness mark/paint (arrowed) on the port/forward corner of the twistlock's underside



Various fracture zones at the welded junction of the top plate and the two side plates can be seen in Figure A6. Of note are the numerous dark zones adjacent to the grey fracture surfaces. These fracture surfaces contained two modes of failure: overload (via lamellar tearing) and crystalline (brittle) fracturing (Figure A7a).

Figure A6: Grey fracture zones on the top plate; note the numerous adjacent dark zones (arrowed)



Fracturing occurred in a plane that was approximately 5 mm from the junction of the side plate to the top plate, i.e. through the parent metal. The aforementioned dark zones (Figure A7b) at the junction of the external butt weld to the top plate consisted of the original surface of the top plate where welding has not occurred (known as lack-of-penetration) and areas adjacent to them where the butt weld metal has not joined to the parent metal (known as lack-of-fusion). During microscopic examination, these latter areas were found to contain porosity, oxides, inclusions, fisheyes, slag and weld spatter.

Figure A7a & b: Crystalline (bright) and overload (grey) fractures in the left photo; lack-of-fusion (gold) and lack-of-penetration (dark grey striations) areas are in the right photo



Given the proportion of the lack-of-penetration zones compared with the total, and that these zones, along with the lack-of-fusion zones, cannot carry any load, it was decided to determine the total area of them plus that of the load-carrying areas (crystalline and overload).

This was done gravimetrically by photographing the underside of the top plate at a suitable magnification (typically by a factor of 2.06 and with a scale ruler alongside), printing the photographs, microscopically ascertaining and marking the two load type areas (load bearing or otherwise), cutting them out with scissors and a scalpel then determining their masses on a laboratory balance.

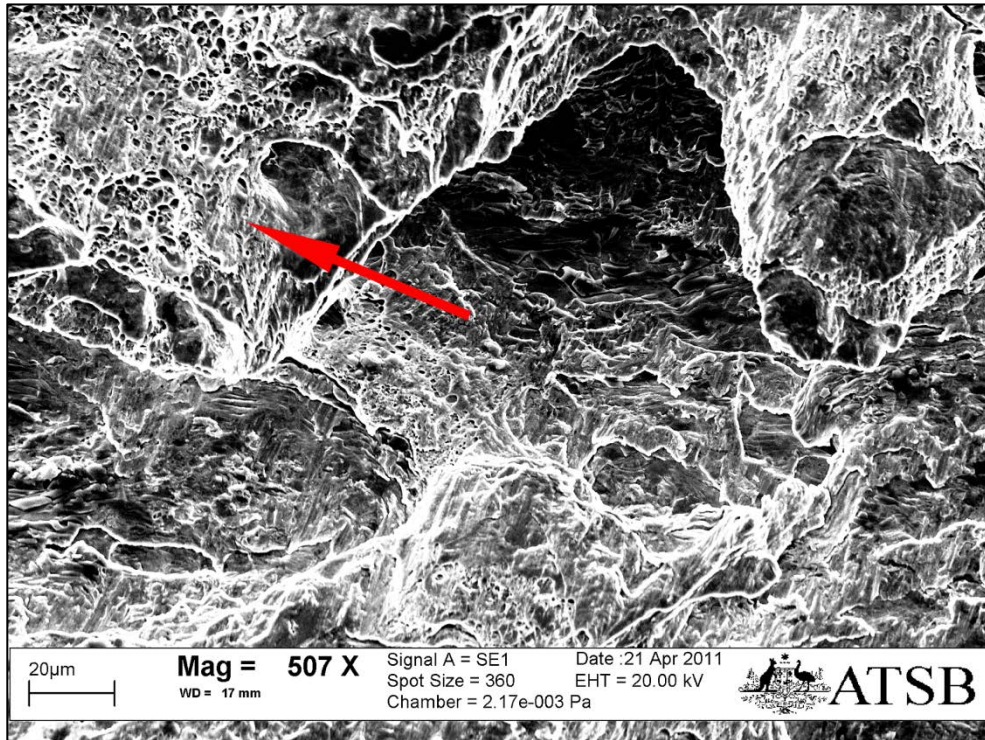
To turn those masses into true areas, the areal mass of the printed paper was determined along with the areal magnification of the prints. The final results are tabled below in Table 1.

Table 1: Measured masses and calculated areas using 0.0000891 g/mm² for printer paper

Areal type	Mass (g)	Area (mm ²)	Proportion %
Load bearing	1.3941	3813	80
Non-load bearing	0.3534	960	20
Total	1.7475	4773	100

A semi-attached piece of fracture surface near the centre of the port side in Figure A6 was removed and examined using a scanning electron microscope (SEM). At higher magnifications, the surface was found to contain both elongated dimples and shear zones (Figure A8).

Figure A8: SEM fractograph showing elongated dimples (arrowed) and shear zones



Examination with respect to drawing specifications

Dimensional measurements, weld assessments, surface condition and hardnesses were made with respect to the MacGregor drawing and drawing notes for the TF-11 (single) twistlock foundation. Dimensional results are listed in Table 2 below.

Table 2: Dimensional results for the twistlock foundation assembly

Dimension (mm)	Measured values	Requirement
Overall width	155, 156 & 157	160 \pm 2
Overall length	156, 158 & 160	160 \pm 2
Distance between side plates	31, 28, 30 & 26	30
Corner radius	28 & 28	28
Side plate width	10 & 10	10
Butt weld leg length	10, 6, 10, 5.5, 5, 9, 6.5, 8, 7, 5 & 9	7
Chamfer on top plate	None detected	8
Fillet weld leg length	7, 9, 4, 7, 7, 8, 4 & 9	4

Notes: Butt weld leg lengths were determined by measuring the distance from the exterior surface of the weld to the junction of the side plate with the fillet weld then subtracting any lack-of-penetration dimension (the dark grey zone in Figure A7b). Also, the required dimension for the top plate chamfer, prior to welding, is a calculated value from a cross section on the drawing.

The weld acceptance standard specified on the drawing is MCG001⁴⁸; relevant visual and dimensional testing criteria for the butt and fillet welds are tabled below in Table 3.

Table 3: Visual weld examination results for both weld types

Feature	Butt weld (Class AS)	Fillet weld (Class AK)
Excess weld metal	>0.9 mm limit (where top plate too narrow)	Pass
Underfilled weld	Pass	Failed in three places
Undercut	None detected	None detected
Fillet leg asymmetry	Not applicable	0.1 mm limit in one place only
Open end craters	Pass	Two detected
Visible pores	None detected	None detected
Visible slag	None detected	None detected
Weld splatter	None observed	None observed
Arc strikes	None detected	None detected
Gas cavities	Two observed	None observed
Cracks	None detected	None detected
Lack of fusion	334 mm total length (specified limit: 0 mm maximum)	None detected
Lack of penetration	1 to 4 mm (3 mm maximum)	None detected

Note: Some feature detectability was limited by still-adherent paint. The 24 lack-of-penetration measurements were made approximately every 15 mm; three were greater than 3 mm.

Although not one of the above visual criteria, a note on the drawing requires ‘all surfaces must be smooth and clean’. Accordingly, the surfaces of the welds and those of the adjacent plates were examined both visually and microscopically. Some areas, such as the butt weld had been abrasive blasted with almost complete removal of the weld’s characteristic topography. By contrast, the fillet weld’s solidification fronts were still easily visible.

TF-11HB denomination foundations require Brinell indentation hardness (HB) tests⁴⁹ (usually a 3,000 kg load⁵⁰) to be performed on the upper surface of the top plate after welding. Lighter Vickers hardness tests⁵¹ were performed at three different loads of 10, 30 and 50 kg to detect any surface hardening or softening. The results were 249HV10⁵² (238HB), 246HV30 (235HB) and 257HV50 (241HB). The drawing minimum for this denomination is 235HB minimum. Additionally, the piece of side-plate parent metal used for SEM examination (Figure A8) was ground

⁴⁸ MacGREGOR specification MCG 001; 09/02: Specification of the quality classes for butt and fillet welds.

⁴⁹ An indentation hardness test named after its proposer, Johan Brinell.

⁵⁰ This leaves a large indent about 4 to 5 mm in size compared with a Vickers indentation that is around 0.1 mm.

⁵¹ A similar indentation hardness test to the Brinell test.

⁵² 249 Hardness Vickers with a 10 kg load.

on one side with 220 grit silicon carbide paper and then Vickers hardness tested. The result of this test was 202HV10.

Analysis

There are two sets of requirements in MacGregor's June 2004 twistlock foundation drawing: specific and functional. The first group covers dimensional, weld acceptability, surface condition and post-weld hardness and the second covers the tensile, shear and compression load requirements.

With respect to the dimensional requirements, the ATSB technical analysis testing identified four notable non-conformances. These cover the overall width/length of the assembly, the butt weld leg length, the butt weld chamfer size on the top plate and the fillet weld leg length.

Firstly, the 1 mm to 5 mm undersized top plate has resulted in some parts of the butt welds being undersized, i.e. below the 7 mm leg length. Compounding this is the almost complete lack of a chamfer prior to the butt welding operation (Figure A7b). However, offsetting this lack of butt weld metal is that most of the fillet weld is well oversize (almost double) except at the narrowest regions of the top plate where it is per the drawing requirement of 4 mm.

Regarding weld acceptability, the narrow area on the top plate resulted in some excess butt weld metal. However, this is not considered to have relevance to the failure mode. There has been some under filling of the fillet weld in three places plus fillet leg asymmetry in one place but failure has not occurred through these four positions.

Of great significance with respect to the other weld acceptability requirements is the large total length of the lack-of-fusion zones compared with total weld length, i.e. 334 mm versus 496 mm⁵³. Further compounding this is the greater-than-specified lack of penetration at three of the 24 positions measured. Both of these features (lack-of-fusion and lack-of-penetration) are noted in the ASM Failure Analysis Handbook⁵⁴ to be the result of an ineffective chamfer⁵⁵. The handbook notes that symptoms of such are oxidised weld metal, flux inclusion, little or no bonding of the weld bead to the surfaces and poor weld penetration, i.e. exactly as noted earlier in this report. Also notable is that the later March 2006 issue of the foundation drawing specifies a full penetration butt weld. It also specifies prototype testing and 'production load testing to be performed under consideration of the consolidated project quantity'.

Although it is not known if this twistlock foundation specified an HB denomination, the foundation's top plate conforms to this hardness requirement in the area tested.

In lifting the 40 foot x 8 foot container to reposition it onto the three remaining twistlocks located in their foundations, it would have to clear their 105 mm height. Over the smallest span of 8 feet, this is a $2\frac{1}{2}^\circ$ angle for the other forward twistlock. With a top plate-to-housing average clearance of 10 mm, i.e. $\frac{1}{2}(4 + 17 \text{ mm})$ over a 160 mm span, i.e. 4° , this should have been possible. However, a lifting of just

⁵³ $4(160 - 30 - 28) + 28\pi$.

⁵⁴ The ASM Handbook, Volume 11 - Failure Analysis and Prevention, p 639.

⁵⁵ An oblique surface cut on the edge or corner of a solid, usually sloping at an angle of 45° .

10 mm by the portainer is a very subtle amount. Hence, it is probable that the container was lifted at least to its stop, i.e. the twistlock's lower cone contacting the underside of the foundation's top plate.

The functional requirements of twistlock components and the foundation have the same nominal breaking load of 500 kN (tensile) and 420 kN (shear). In addition, the foundation has safe working load (SWL) limits of 250/210 kN and 375/315 kN for proof load. For tensile-only loads, these equate to 25, 38 and 51 tonnes. Given that the failed foundation was at one corner of the unlatched 29 tonne hatch cover, the fulcrum would have been on the diametrically opposite corner. Thus, the load being inadvertently lifted via the single twistlock was 14½ tonnes, i.e. approximately 60% of its SWL or 30% of its nominal breaking load.

However, the specified loads with ratios of 1:1½:2 look to be truly nominal and/or highly conservative. Hence, it was decided to see what the twistlock foundation in question was capable of in a purely tensile load case.

In looking at the three materials specified in MacGregor's technical data sheet for the foundation assembly i.e. the top plate, the as-welded welding wire and the side plate, the specified side plate material, S355J263⁵⁶, has the lowest-specified, minimum ultimate tensile strength (UTS) of the three in the as-supplied condition. This is from its UTS range of 490 to 630 MPa along with a specified minimum tensile yield strength of 355 MPa (the second, third and fourth digits in the specification nomenclature). However, this is for the as-supplied plate and not that in the heat affected zone of the welds, hence the need to test the semi-attached piece of parent metal. That piece's hardness of 202HV10 converts to a tensile strength of 634 MPa, i.e. very similar to the maximum specified UTS of 630 MPa.

In using the measured load-bearing area of 3,813 mm², the 355 MPa yield and 630 MPa UTS translate to 1,350 kN and 2,400 kN (138 and 245 tonnes) respectively. As the latter is almost seventeen times that of the weight of half the hatch cover, then the load case cannot have been a purely tensile one. This is confirmed by the dual fracture modes observed in Figure A8.

It was noted in the report's narrative that the ship was trimmed by the stern i.e. it was not on an even keel. As well, lifting of one corner of the hatch cover results in the container being lifted being at an angle in both the fore/aft and port/starboard directions, i.e. also not horizontal. The lower cone was measured to have a permanent set of 4° relative to the twistlock's centre shaft. Inspection of Figure A1a shows this cone to have been positioned in the port/starboard direction, i.e. locked. Further, it was observed that there were mating witness marks on each port/forward corner of the twistlock housing and the top plate.

That corner is diametrically opposite to the fulcrum point of the lifted hatch cover. Thus, a bending load was applied to the aft/starboard corner of the foundation top plate. However, there is a very large applied leverage via the 180 mm between the two corners of the top plate and the container's diagonal length of 41 feet (12.5m), i.e. a 70:1 leverage ratio. This magnified load was applied to the two welded junctions of the side plates to the top plate i.e. the top right corner in both Figures A1a and A6.

⁵⁶ One of the grades specified in European Structural Steel Standard EN 10025: 2004.

Further compounding this elevated stress is that butt welding is known to induce high tensile residual stresses in the weld and adjacent heat-affected zones⁵⁷. To put their significance in context, a maximum of +250 MPa was measured in one butt-welded example⁵⁸; being tensile, these stresses are in addition to the applied stress. Some of these stresses may have been partly counteracted by the abrasive blasting, albeit highly uneven; however, such blasting creates a rougher, stress-raising surface compared with shot peening⁵⁹.

Summary

The failure of *Vega Gotland*'s twistlock foundation assembly was consistent with its exposure to gross overstress conditions. The weld fractures and bent hardware are consistent with a combination of tensile, bending and shear loads generated during the reported asymmetric lifting of the partly secured container and the unsecured hatch cover. The angle of the hatch cover, due to the vessel's stern trim, applied a magnified leverage to the foundation and this contributed significantly in the failure of the welds.

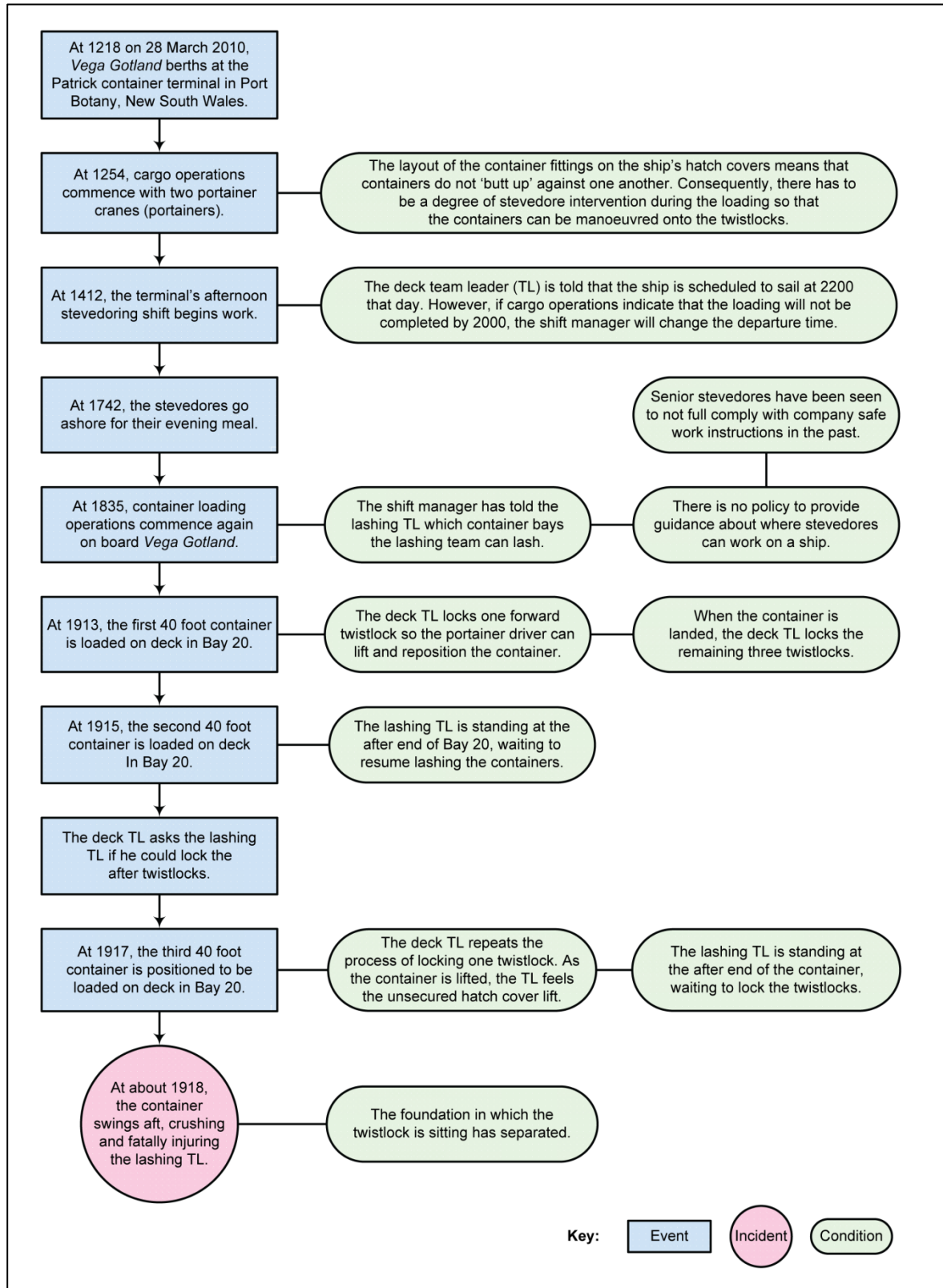
While the ATSB's technical examinations found that the welds joining the foundation top plate to the side plates were not in compliance with engineering and design specifications, the deficiencies were not at a level likely to have had a major detrimental effect on the overall strength of the assembly.

⁵⁷ Hilley, M. (Ed). *Residual stress measurement by X-ray diffraction - SAE J784a*. Society of Automotive Engineers.

⁵⁸ Rigaku Corporation (an analytical X-ray instrument maker) Application Report #10.

⁵⁹ The process of cold forming the surface of a part by means of a propelled stream of round hardened steel shot. The result of this process is a uniformly dimpled surface, the roughness being determined by the shot size and the peening intensity.

APPENDIX B: EVENTS AND CONDITIONS



APPENDIX C: SHIP INFORMATION

Vega Gotland

IMO Number	9336347
Call sign	V2BP4
Flag	Antigua and Barbuda
Port of Registry	St Johns
Classification society	Bureau Veritas (BV)
Ship Type	Cellular container ship
Builder	Kouan Shipbuilding Industry, Taizhou, China
Year built	2005
Owners	MS Vega Gotland Schiffahrtsgesellschaft, Germany
Ship managers	Vega Reederei Friedrich Dauber, Germany
Gross tonnage	9,957
Net tonnage	5,020
Deadweight (summer)	13,996 tonnes
Summer draught	8.50 m
Length overall	147.74 m
Length between perpendiculars	140.30 m
Moulded breadth	23.25 m
Moulded depth	11.50 m
Engine	1 x MAN B&W 7L58/64
Total power	9,732 kW
Speed	19.0 knots
Crew	20

APPENDIX D: SOURCES AND SUBMISSIONS

Sources of Information

The sources of information during the investigation included:

The master and crew of *Vega Gotland*

Patrick Terminals

The Australian Department of Education, Employment and Workplace Relations

The Australian Maritime Safety Authority

The Maritime Union of Australia

The NSW Police Service

The WorkCover Authority of NSW

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Submissions

Under Part 4, Division 2 (Investigation Reports), Section 26 of the *Transport Safety Investigation Act 2003*, the ATSB may provide a draft report, on a confidential basis, to any person whom the ATSB considers appropriate. Section 26 (1) (a) of the Act allows a person receiving a draft report to make submissions to the ATSB about the draft report.

A draft of this report was provided to the owners of *Vega Gotland*, Patrick Terminals (Patrick), the shift manager, the stevedore deck team leader, the portainer driver, the trainee lashers interviewed by the ATSB, the Maritime Union of Australia (MUA), the WorkCover Authority of NSW (WorkCover), the Australian Maritime Safety Authority (AMSA), the New South Wales police service, and the New South Wales Coroner.

Submissions were received from the owners of *Vega Gotland*, Patrick, the shift manager, the stevedore deck team leader, the portainer driver, the trainee lashers, the MUA, WorkCover and AMSA. The submissions were reviewed and where considered appropriate, the text of the report was amended accordingly.

Independent investigation into the stevedore fatality on board the Antigua and Barbuda registered container ship *Vega Gotland* at Port Botany, New South Wales on 28 March 2010.