



Australian Government

Australian Transport Safety Bureau



ATSB TRANSPORT SAFETY INVESTIGATION REPORT

Marine Occurrence Investigation No. 221

Final

Independent investigation into the serious injury of a
crew member onboard the Australian flag bulk carrier

River Embley

off the Port of Gladstone, QLD

14 October 2005



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Independent investigation into the serious injury of a crew member on board the Australian flag bulk carrier *River Embley* off the port of Gladstone, Queensland, 14 October 2005

Prepared by

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Abstract

River Embley arrived at the anchorage off Gladstone at 0902 on the morning of 14 October. After 'finished with engines', the diesel alternator was put on line and the steam plant was shut down to allow for repairs on the number two turbo alternator exhaust steam valve.

At about 1010, after checking that the exhaust steam system had drained, the chief engineer and third engineer started working on the valve. A short time later, while they were dismantling the valve a thousand litres of pressurised hot water unexpectedly started to spray from the valve and onto the chief engineer standing on staging below.

In an effort to escape the hot water spray the chief engineer tried to jump clear of the staging but became entangled in the securing rope which had formed a barrier.

The ship's crew mounted an immediate first aid response and the master organised a helicopter evacuation. The chief engineer was transported to Gladstone Hospital and later transferred to the Royal Brisbane Hospital intensive care unit.

The report concludes that the engineers did not fully assess the exhaust steam piping system and its drainage arrangements, or allow sufficient time for the exhaust steam system to completely drain before starting to work on the valve.

The ship's work permit system and job safety analysis procedures were not utilised by the engineering crew and deficiencies in safety management were not identified in two audits prior to the accident.

It is also considered that a sizable experience gradient between the chief engineer and the other engineers along with a lack of team training allowed a series of 'single person' errors to go unchecked and unquestioned.

The ATSB has made several safety recommendations aimed at preventing further accidents.

THE AUSTRALIAN TRANSPORT SAFETY BUREAU

The Australian Transport Safety Bureau (ATSB) is an operationally independent multi-modal Bureau within the Australian Government Department of Transport and Regional Services. ATSB investigations are independent of regulatory, operator or other external bodies.

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. Accordingly, the ATSB also conducts investigations and studies of the transport system to identify underlying factors and trends that have the potential to adversely affect safety.

The ATSB performs its functions in accordance with the provisions of the Transport Safety Investigation Act 2003 and, where applicable, relevant international agreements. The object of a safety investigation is to determine the circumstances to prevent other similar events. The results of these determinations form the basis for safety action, including recommendations where necessary. As with equivalent overseas organisations, the ATSB has no power to implement its recommendations.

It is not the object of an investigation to determine blame or liability. However, it should be recognised that an investigation report must include factual material of sufficient weight to support the analysis and findings. That material will at times contain information reflecting on the performance of individuals and organisations, and how their actions may have contributed to the outcomes of the matter under investigation. 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.

Central to the ATSB's investigation of transport safety matters is the early identification of safety issues in the transport environment. While the Bureau issues recommendations to regulatory authorities, industry, or other agencies in order to address safety issues, its preference is for organisations to make safety enhancements during the course of an investigation. The Bureau is pleased to report positive safety action in its final reports rather than make formal recommendations. Recommendations may be issued in conjunction with ATSB reports or independently. A safety issue may lead to a number of similar recommendations, each issued to a different agency.

The ATSB does not have the resources to carry out a full cost-benefit analysis of each safety recommendation. The cost of a recommendation must be balanced against its benefits to safety, and transport safety involves the whole community. Such analysis is a matter for the body to which the recommendation is addressed (for example, the relevant regulatory authority in aviation, marine or rail in consultation with the industry).

1 SUMMARY

River Embley arrived at the anchorage off Gladstone at 0902 on the morning of 14 October. After 'finished with engines', the diesel alternator was put on line and the steam plant was shut down to allow for repairs on the number two turbo alternator exhaust steam valve.

At about 1010, after checking that the exhaust steam system had drained, the chief engineer and third engineer started working on the valve. A short time later, while they were dismantling the valve, hot condensate unexpectedly started spraying from the gap between the valve's bonnet and body.

In an effort to escape the hot condensate spray, the third engineer fled inboard. He was unhurt. At the same time the chief engineer jumped aft to clear the staging and became entangled in the rope securing it. The hot condensate sprayed onto the chief engineer.

The third engineer went to the chief engineer's assistance and freed him from the rope and helped him to the nearby emergency shower.

The bridge was notified and the chief mate and third mate went to the engine room to assist. It was apparent that the chief engineer would need medical assistance. The master was informed, and he contacted the company's Gladstone office requesting an immediate helicopter evacuation.

At 1204, the rescue helicopter landed on board *River Embley*.

With assistance from the ship's crew and the paramedic, the chief engineer walked to the helicopter, and at 1234, the helicopter departed the ship.

The chief engineer was transported to Gladstone Hospital, where he was assessed as having burns to 45 percent of his body. He was later transferred to the Royal Brisbane Hospital intensive care unit.

The report finds that when the valve was cracked open, the condensate in the pipe between the valve and the exhaust steam range sprayed from the partially dismantled valve.

The report concludes that the control measures outlined in the vessel's safety management system were not implemented and the engineers did not fully assess the exhaust steam piping system, and its drainage arrangements or allow sufficient time for the exhaust steam system to completely drain.

It is considered that if they had been implemented, the safety management system procedures and associated checklists would not have ensured adequate protection for the engineers working on the steam valve. It is also possible that a sizable experience gradient between the chief engineer and the other engineers, along with a lack of team training, allowed a series of 'single person' errors to go unchecked and unquestioned.

It is also considered that the quick action of all concerned in administering first aid and facilitating a timely helicopter evacuation assisted in minimising the effect of the injuries sustained by the chief engineer.

2 SOURCES OF INFORMATION

The master and crew of *River Embley*

The Australian Maritime safety authority

ASP Ship Management

The Capricorn Helicopter Rescue Service

References

R Nijjer, *Bridge Resource Management: The Missing Link*, Sea Australia, Sydney, 2000.

Seafarer's Training, Certification and Watchkeeping (STCW) Code, International Maritime Organization, 1995.

3 NARRATIVE

3.1 *River Embley*

River Embley is an Australian registered bulk carrier. It was specifically designed for the bauxite trade between the Queensland ports of Weipa and Gladstone, through the inner route of the Great Barrier Reef. The ship is managed by ASP Ship Management (ASPSM), Australia, and is classed with Lloyds Register of Shipping (LR).

River Embley was built in 1983 by Mitsubishi Heavy Industries, Nagasaki, Japan. The ship has an overall length of 255 m, a beam of 35.35 m and a depth of 18.29 m. It has a deadweight of 76 358 tonnes, at its summer draft of 12.321 m.

The ship has three cargo holds located forward of the accommodation. The holds are serviced by eight hatches.

Propulsive power is provided by a single 13 976 kW Mitsubishi MS-21-2 marine steam turbine, driving a five bladed highly skewed propeller through a reduction gearbox. This gives the ship a service speed of 14.5 knots.

Figure 1: *River Embley*



At the time of the incident, *River Embley*'s crew comprised a master, three deck officers, five engineers, seven integrated ratings, two caterers and two trainees. They were all Australian nationals.

The deck officers maintained a watchkeeping routine of four hours on, eight hours off. The engineers followed a 24 hour duty roster with the engine room operating un-manned outside normal working hours.

The master on board *River Embley* at the time of the incident held a master class one certificate of competency, and had 36 years seagoing experience. He had been master of *River Embley* for a month and was completing his first tour of duty on the ship. This was his first permanent command.

The third mate, the medical officer on board *River Embley*, held a master class one certificate of competency. He first went to sea in 1955, and then took a shore position in 1967. He served in various positions within a number shipping companies, up until the time he retired. Since retiring he has returned to sea on a casual basis. He had been on board the ship for one month and was completing his first tour of duty on the ship.

The chief engineer on board *River Embley* at the time of the incident had 44 years seagoing experience. After sailing on a variety of vessels, he gained his combined steam and motor first class certification in 1968. He had been on board *River Embley* for six weeks on this occasion. He had been sailing on board *River Embley* since it came into service in 1983. He had spent all but four of the last 23 years serving on the ship.

The third engineer on board at the time of the incident held an engineer watch keeper certificate of competency, and had nine years seagoing experience. He had been on board *River Embley* for two weeks on this occasion, and had been sailing on the ship for four years.

3.2 The steam plant

River Embley is fitted with two coal-fired high pressure boilers, which were designed by Associated Combustion, and built by Mitsubishi Heavy Industries. They were specifically designed to burn the type of bunker coal that is readily available from Gladstone.

The coal is stored in bunkers located aft of the accommodation superstructure (Figure 1). The coal is transferred from the bunkers to daily hoppers using a densoveyor¹ system. Coal is supplied as required from the daily hoppers, to a set of three spreaders, which feed coal onto a moving chain grate in the furnace. The heat in the furnace ignites the coal, which then burns as the grate moves it through the furnace. At full sea speed the boilers consume approximately 250 tonnes of coal per day.

Residual ash is removed from the boiler ash hoppers by a lean phase vacuum system, bottom ash is crushed before being transferred to storage hoppers. The ash is eventually disposed of in approved areas at sea.

The boilers are water tube boilers and each is fitted with a superheater. They are rated at 480° Celsius and 60 Bar². The boilers produce approximately 64 000 kilograms of steam per hour.

The high pressure superheated steam is supplied from the boilers to the main propulsion turbine, two turbo alternators and two feed pumps. The exhaust steam

1 High volumes of low pressure air are used to push slugs of coal through pipes.

2 1 Bar = 1 kg/m² or 100 kPa.

from these units is fed through the de-aerator, main boiler air heaters and the evaporators, which makes use of the residual heat in the exhaust steam. Any excess exhaust steam is dumped into the main condenser.

3.3 The incident

After completing a three day dry-docking at Garden Island Dockyard, *River Embley* departed Sydney for Gladstone at 1340 local time (UTC+11) on 11 October 2005. The ship was due to anchor on arrival off Gladstone on 14 October. The voyage was generally uneventful. The weather conditions throughout the voyage were good, with slight seas and low swell.

During the voyage the master and chief engineer discussed the upcoming anchorage. The chief engineer informed the master that he would carry out some maintenance on the steam plant while the ship was at anchor. The chief engineer was aware that the duration of the anchorage would be approximately 15 hours and he assured the master that the repairs would be completed in that time.

Prior to arriving off Gladstone, the engine room staff prepared for the replacement of the bonnet joint on the number two turbo alternator exhaust steam isolating gate valve (TAV2). Staging was set up beneath the TAV2, and mounted between a pair of ladders and the hand railings; it was also tied off to stop it from moving (Figure 2). Two bonnet retaining bolts were removed from the valve, and replaced with lengths of threaded bar and nuts. The threaded bar and retaining nuts would be used to control the lowering of the valve bonnet, as the valve was heavy and overhead (Figure 3).

Figure 2: The No. 2 turbo alternator exhaust steam valve and staging

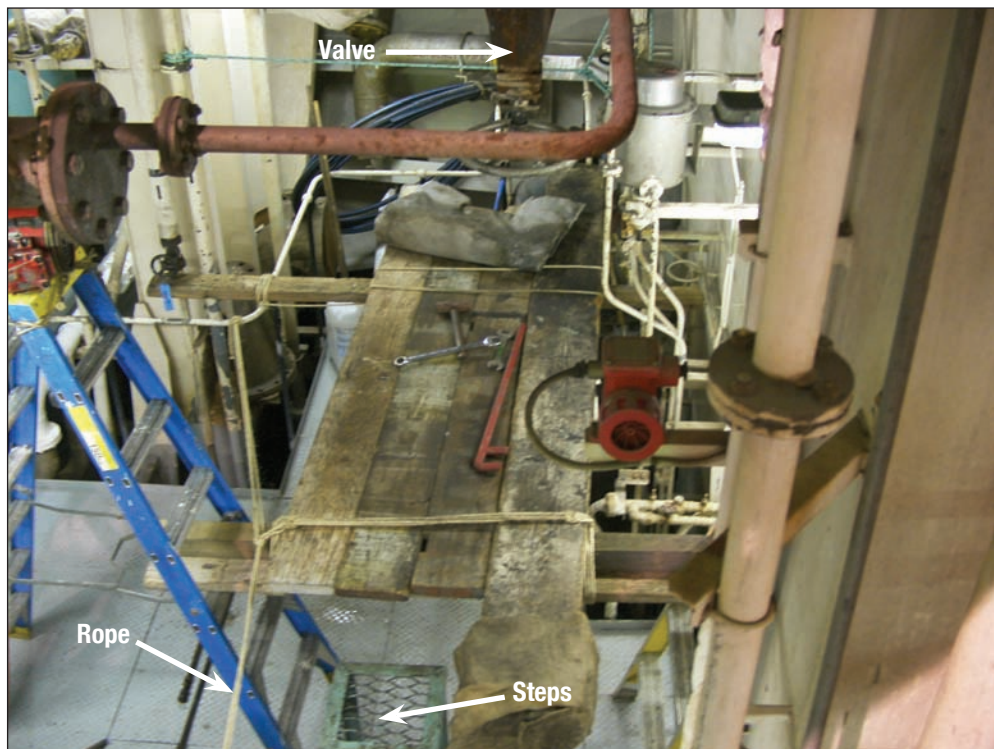
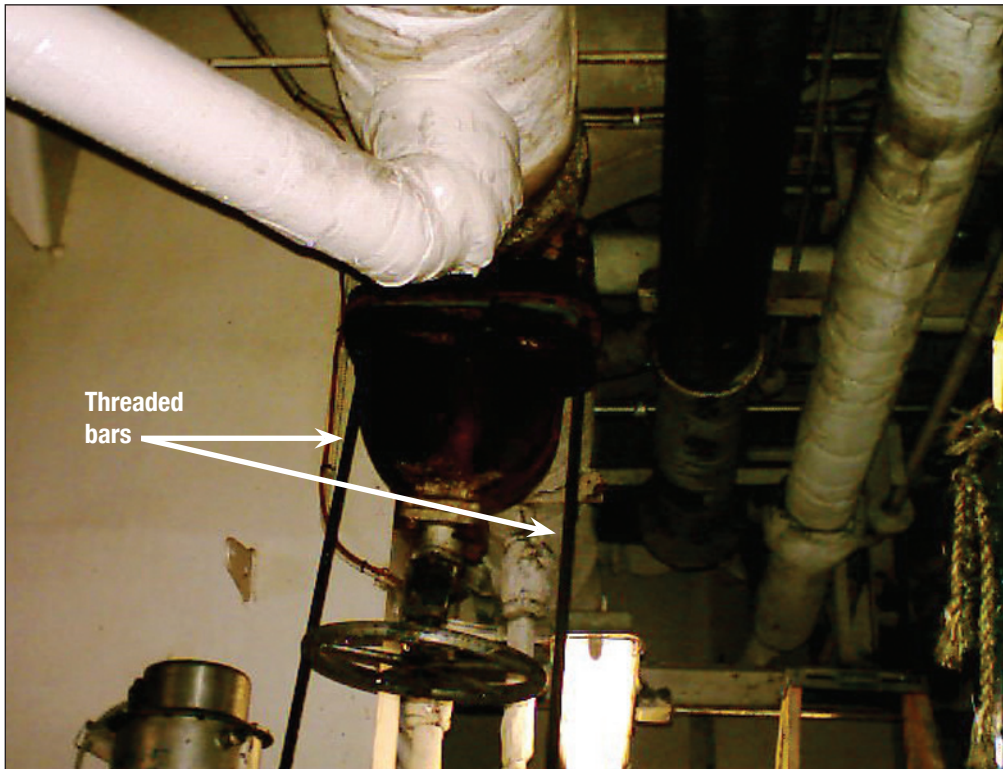


Figure 3: The No. 2 turbo alternator exhaust steam valve and threaded bars



At about 0700 on 14 October, the first engineer, chief mate and chief integrated rating discussed the day's work schedule. They discussed the repairs to the leaking bonnet joint on the TAV2, and during this discussion reference was made to a job safety analysis (JSA), titled 'steam valves'. The safety measures referred to in this JSA were to be followed when carrying out the repairs.

At about 0800 the first engineer discussed this same task with the engine room staff. The third engineer was assigned to assist the chief engineer with the replacement of the leaking joint. The second and fourth engineers were allocated the job of replacing the bonnet joint on another steam valve. It was determined that both jobs could be done at the same time and that neither would interfere with the other. Again the 'steam valves' JSA was referred to; however no work permits were issued.

The ship arrived off Gladstone and the anchor was let go at 0837 local time (UTC+10) on 14 October. The master rang 'finished with engines' at 0902.

After 'finished with engines' in addition to the normal engine room shutdown procedures, the diesel alternator was put on line and the turbo alternators were shut down. This would allow the work on the valves to be carried out. The normal routine when shutting down the turbo alternators was to isolate the supply and exhaust steam and then open the turbine casing drain valve. It was also normal to open the turbo alternator stop valve bypass to assist in keeping the turbo alternator warm. The chief engineer had specifically asked that the heating steam valve should be left closed because of the work that was planned on the steam valves.

The chief engineer had decided that it would be necessary to shut down the steam plant to allow for the steam valve repairs. The routine for shutting down the plant was for the chief engineer to remain in the control room while the other engineers carried out his instructions. They followed a process of shutting down the boilers and isolating the steam system. All valves that were closed were recorded in the control room.

The chief engineer asked one of the engineers to jack open the de-aerator relief valve, to vent the exhaust steam system, and thus assist with the draining of the exhaust steam line. He also asked the first engineer to check that the de-aerator relief valve had been jacked open.

At about 1010, the chief engineer asked the third engineer to meet him at the TAV2. The chief engineer went to the TAV2 and checked that the drain to atmosphere was open and had finished draining, he checked the system pressure, and there was no indication that there was any pressure in the exhaust steam line. When he determined that the system had stopped draining, he started working on the TAV2.

When the third engineer arrived at the valve, the chief engineer was already on the staging. The third engineer joined him, and the two men started removing the bolts from the valve bonnet. When all the bolts were removed, the bonnet was held in place by the two threaded bars and their retaining nuts. The two men slackened off the nuts on the threaded bars so they could break the bonnet gasket seal and then broke the seal by shaking the valve bonnet. When the seal was broken, both men stood clear as they expected a small quantity of condensate to drain out of the one centimetre gap between the valve body and the bonnet. At this point about five to ten litres of condensate drained from the valve.

After allowing the condensate to drain from the valve the two men continued to lower the valve bonnet by further slackening the nuts on the threaded bars, however the valve bonnet was not lowering with the retaining nuts as expected. It appeared that the valve gate was jammed in its sealing faces, and thus holding the bonnet up. The chief engineer asked the third engineer to get a wheel key. When the third engineer returned with the wheel key, the chief engineer used it to crack open the valve.

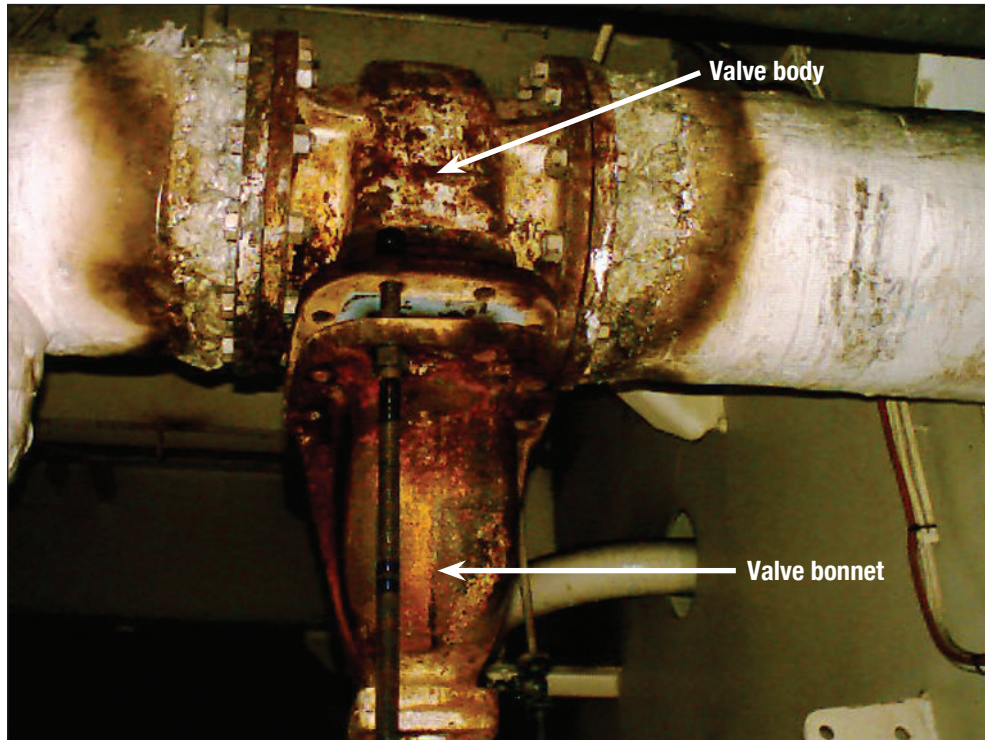
When the valve was cracked open the bonnet suddenly dropped about two centimetres. The valve bonnet was now three centimetres clear of the valve body (Figure 4). Hot condensate unexpectedly started spraying out from the gap between the valve's bonnet and body. The condensate sprayed out horizontally in all directions and as far as two metres from the valve.

In an effort to escape the hot condensate spray the third engineer fled inboard and down a set of steps that were in place to allow access to the staging. He was unhurt. The chief engineer jumped aft to clear the staging and got entangled in the ropes securing the staging (Figure 2). When seen by the third engineer; he had one leg on either side of the securing rope and he had fallen forward.

It was apparent that the chief engineer was in difficulty and getting sprayed with the hot condensate. The third engineer went to his assistance, however, it took about

one minute to get the chief engineer clear as he was struggling to free himself, and the third engineer was trying to avoid being scalded. Once the chief engineer was free, the third engineer helped him to the near-by cold sea water emergency shower, which was about ten metres away, to cool the chief engineer's burns. The third engineer assisted the chief engineer with the removal of his overalls while he was under the shower.

Figure 4: TAV2 showing the bonnet three centimetres clear of the valve body



The second engineer, working on the deck above, saw a large cloud of steam rising from below. He went to investigate and saw the chief engineer in the shower, and the third engineer assisting him. He asked the third engineer what help was needed, and then went to the engine control room to notify the bridge.

At about 1015, the second engineer rang the bridge and informed the third mate of the incident. The third mate left the bridge, and on his way to the ship's hospital to pick up the burns kit, he informed the master and chief mate. The master went to the bridge and the third mate, accompanied by the chief mate, went to the engine room.

It was immediately apparent that the chief engineer would require greater medical assistance than was available on board the ship, and so the chief mate telephoned the bridge and informed the master. At 1040, the master telephoned the ship manager's office in Gladstone, requesting an immediate helicopter evacuation for the chief engineer.

The chief mate, third mate and third engineer agreed that it would be best to move the chief engineer to the ship's hospital, where they thought the chief engineer could be placed in a saline bath. They would also have access to better facilities and

communication in the hospital. With some assistance, the chief engineer walked to the lift, and made his way to the hospital.

By 1100, the chief engineer was in the ship's hospital. However, he could not sit in the saline bath due to the pain caused by his burns. It was decided to continue the cooling process in the hospital shower and to use the ship's supply of saline solution to irrigate his burns.

Throughout the incident the chief engineer remained conscious and lucid; he also drank about three litres of water.

At 1206, the Rockhampton based Capricorn Rescue Service helicopter, with a paramedic on board, landed on board *River Embley*. The paramedic was led to the hospital, where he carried out a medical assessment of the chief engineer's condition. The paramedic decided that the chief engineer required hospitalisation as soon as possible. With assistance from the ship's crew and the paramedic, the chief engineer walked to the helicopter. At 1236, the helicopter departed the ship. The chief engineer was transported to Gladstone Hospital where he was assessed as having burns to 45 percent of his body.

During his treatment it was decided that the chief engineer required more care than could be offered in Gladstone. The next morning he was air lifted by the Royal Flying Doctor Service to the Royal Brisbane Hospital, where he was admitted to the intensive care unit.

4 COMMENT AND ANALYSIS

4.1 Evidence

On 15 October 2005, two investigators from the Australian Transport Safety Bureau (ATSB) attended *River Embley* in Gladstone. The master and directly involved crew members were interviewed, and they provided accounts of the incident. Copies of relevant documents were obtained including log book entries, procedures and statutory certificates.

On 16 January 2006, shortly after he was discharged from hospital, the chief engineer was interviewed at his home. He provided an account of the incident.

Information was also gathered from ASP Ship Management (ASPSM) and the Australian Maritime Safety Authority (AMSA).

4.2 The valve

The turbo alternator exhaust steam valve is a 250 millimetre diameter gate valve. It is located one deck below the turbo alternator, at the bottom of a loop in the exhaust steam pipe work (Figures 3, 4 and 5). The valve is inverted, and consequently it is accessed from below.

The valve first started leaking after the steam plant was flashed up prior to the ship's departure from Sydney. The leak was from the gasket between the valve's bonnet and body. It was not unusual on board *River Embley* for exhaust steam joints to blow out during the flash-up process. This is primarily due to the age of the plant and the water hammer in this area of the system during the warm through process.

The number two turbo alternator could not be operated due to the steam leakage from the TAV2, and hence it was important that this valve was repaired promptly, thus ensuring the vessel had the use of this important piece of machinery as soon as possible.

Its position in the steam system meant that it was not possible to isolate the valve for the repair without shutting down the entire steam plant.

The chief engineer took the opportunity to repair the steam leak while the ship was at anchor as he believed there was sufficient time available to complete the task and the favourable weather conditions would allow him to disable the ship's propulsion system. He was planning to go on leave in Gladstone and wished to have the repairs completed before the new chief engineer arrived on board.

4.3 The staging

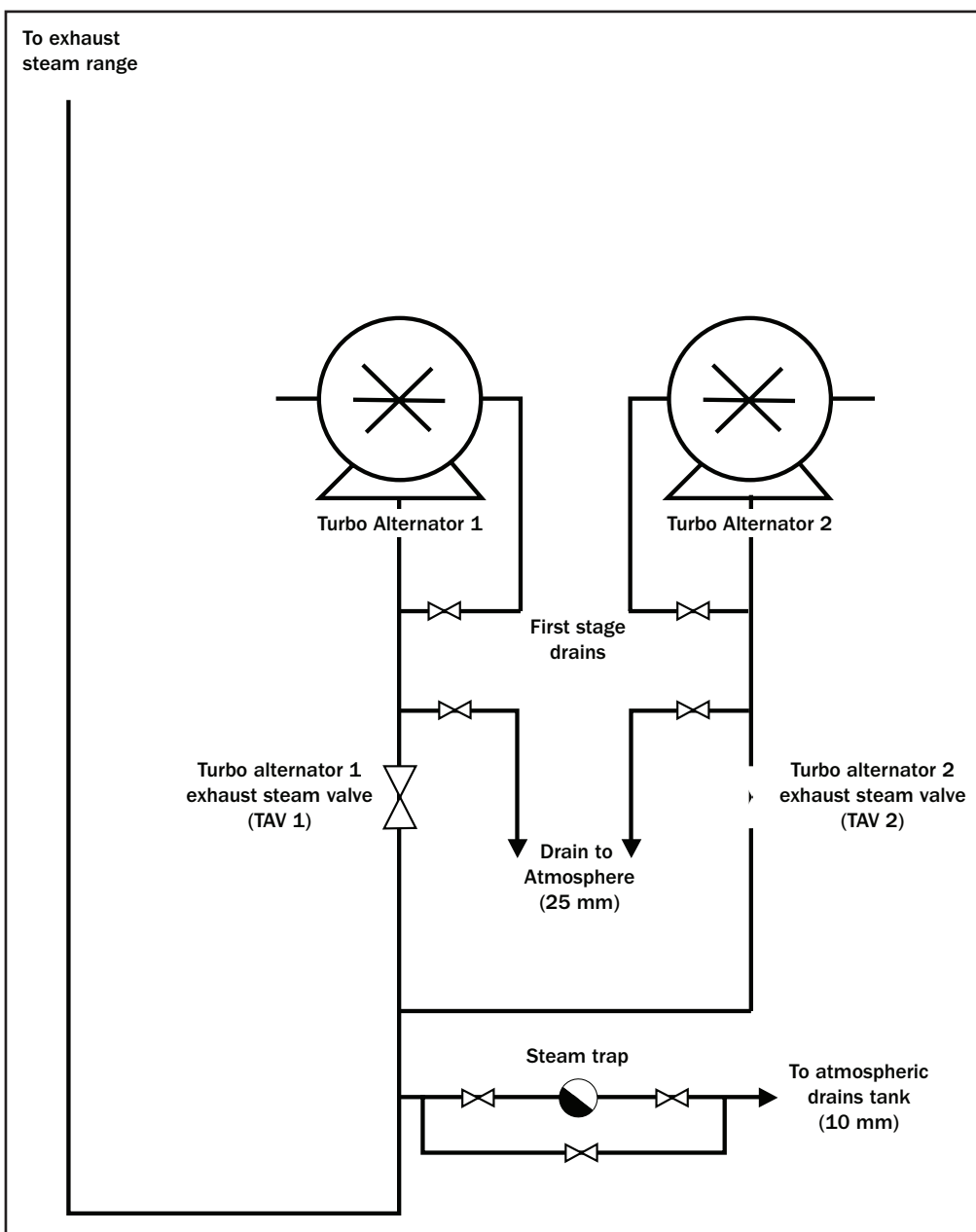
The staging was setup by the chief engineer during the afternoon of 13 October. It was constructed from two 100 mm x 100 mm bearers, supporting four 250 mm x 50 mm planks (Figure 2). The entire staging was supported by the hand rails and a pair of ladders. The planks, bearers, railings and ladders were lashed together using

a single length of rope that was nearby at the time. The rope was too long for its intended purpose; hence it was led from railing to railing and tied off the ladders, as well as the inboard and outboard bearers.

While the staging was strong and large enough for its intended purpose, it was the securing rope that proved to be the problem. The chief engineer became entangled in the securing rope as he attempted to avoid the hot condensate (Figure 2). Had each section of the staging been lashed off with separate ropes, or in a fashion that did not lead to the rope forming a perimeter barrier at the aft end of the staging, he may well have escaped with only minor injuries.

In this instance, not keeping the workplace clear of unnecessary obstructions proved to be a major contributing factor that led to the chief engineer sustaining his injuries.

Figure 5: Schematic diagram of part of the steam system



4.4 Draining the system

The location of the TAV2 in the system meant that it was usual for some condensate to drain to its location when the steam plant is shut down. Consequently the sections of pipe work on either side of the valve are fitted with drain lines (Figure 5).

A 25 millimetre drain line on the turbo alternator side of the TAV2 drains to atmosphere (bilge), and is isolated by a valve. It is the normal routine on board *River Embley* to open this valve when the turbo alternator is shut down. On 14 October this drain valve was opened and the chief engineer checked that it had completed draining, before he started work on the TAV2.

The second drain, a 10 millimetre line fitted after the valve, drains to the atmospheric drains tank via a steam trap. The steam trap and associated isolating valves are fitted with a by-pass line and an isolation valve (Figure 5), this valve was also opened on 14 October. This line drains to a closed system and thus it was not possible to check if it had fully drained the section of pipe between the TAV2 and the exhaust steam range, located some decks above.

River Embley's steam propulsion plant is a large system, and it is conceivable that it could take many hours for this part of the steam system to completely drain through a 10 millimetre drain line. The only way to determine if this section of pipe is in fact fully drained is to open or partially open the TAV2, and hence open up this section of the exhaust steam system to the atmospheric drain. With the TAV2 open, the drain to atmosphere (bilge) can drain both sides of the TAV2.

At the start of repairs on the TAV2 on 14 October, the valve was closed, as is normally the case when the turbo alternator is shutdown. The chief engineer and third engineer were expecting some condensate would drain from the valve when they broke the bonnet seal, and they were prepared for that, and stayed well clear while it drained.

The initial five to ten litres of condensate that drained from the valve was probably from the valve bonnet space. It was not until the valve gate was cracked open and clear of its sealing faces that the condensate in the pipe after the valve started to spray from the three centimetre gap between the valve's bonnet and body (Figure 4). It was this subsequent spray of about 1000 litres³ of condensate that caught the men by surprise.

If the engineers had opened the TAV2 and then allowed the system sufficient time to drain through the atmospheric (bilge) drain they could have physically confirmed when the exhaust steam piping on both sides of the TAV2 was drained empty.

³ The quantity of condensate was estimated by the ship's engineers. This estimation considered the amount of water pumped from the bilges on that evening and eye witness accounts.

4.5 Timing

The master rang 'finished with engines' at 0902 on 14 October. The engineers then went about shutting down the steam plant to allow the repairs on the TAV2 to be carried out. By about 1010 the steam plant was shut down, and after checking that the flow from the atmospheric drain had stopped, the chief and third engineer started working on the TAV2.

While the steam plant is shut down it is also cooling. Consequently the longer it is shut down, the longer it will take to warm it up again, thus there is always pressure to minimise shutdown time. Given the limited time at anchor the engineers needed to consider this factor when deciding how long to allow the system to drain and cool. While the chief engineer's decision to start work immediately was no doubt well intentioned, it is possible he placed too much pressure on himself to complete the job quickly. It would have been prudent to allow the system more time to drain, and cool down, before starting the repairs.

4.6 The safety management system

On 18 August 2005 *River Embley's* management company issued the ship with a new safety management system. The aim of the system change was to allow the company to implement a standardised and simpler system over its entire fleet. The master and crew were given an introduction to the new system and asked to review the system and implement it over the next few weeks. The intention was to phase in the new system during a scheduled roll out period.

Due to the workload on board *River Embley*, and a number of perceived deficiencies in the new system, the ship's masters had decided to implement the change progressively. It was thought that there was a need to keep parts of the old system in place initially because there were areas of the ship's critical engine room operations that were not covered by the new safety management system. The intention was to phase out the old system as the new system became an acceptable replacement.

As a consequence of the progressive roll out, the work permit component of the new safety management system was not in use on board *River Embley* on 14 October.

The system operating on board the *River Embley* at the time of the incident contained no specific procedure for the repair of a steam valve. It did however require that the following precautions be followed when completing a repair such as the one carried out on the TAV2:

- Tag or lock out any valves that if inadvertently opened could endanger those people working on the valve.
- Complete a 'Hazardous Work Permit'.
- Complete a job safety analysis (JSA), or refer to a previously completed JSA.

In submission ASPSM stated:

Had a job specific JSA been prepared as provided for in the safety management system or the 'Pipelines and pressure vessel permit' under the quality management system that was in roll out phase at the time been followed, this would have ensured adequate protection.

If the new safety management system had been implemented prior to 14 October the engineers would have been required to carry out the following:

- Tag or lock out any valves that if inadvertently opened could endanger those people working on the valve.
- Complete a 'Pipelines and pressure vessels permit'.
- Complete a job safety analysis (JSA), or refer to a previously completed JSA.

The new 'Pipelines and pressure vessels permit' is more specific than the 'Hazardous work permit' it replaced, and includes the following question.

Has the pressure been bled off the part of the system to be worked on by opening drain cocks or vents as appropriate and ensuring that pressure remains off?

While more specific, the new permit would not have ensured the protection of the engineers working on the valve. The engineers had referred to a JSA. They opened the vent and drain valves, and checked that the pressure had been bled off. What they had not done was ensure that the exhaust steam system was completely drained of condensate.

4.7 Safety management on 14 October 2005

In preparation for the TAV2 repair, the task was discussed at the daily works meeting, and later with the engineering staff. At both times the JSA titled 'steam valves' (Figure 6) was referred to. This JSA notes that it is generic, and it was not specifically for the turbo alternator exhaust valve. While both the old and new safety management systems allow the use of a previously completed JSA, this particular JSA was not complete in its analysis and was not signed off as being analysed, reviewed or approved. The JSA did not identify all the risks associated with completing the TAV2 overhaul.

The chief engineer had implemented some control measures. He constructed a sturdy staging, ensured the engineers and crew were well briefed, recorded the valves that had been closed when the steam plant was shut down, and ensured that both he and the third engineer had all the appropriate personal protective equipment. However, he had not followed the requirements of the vessel's safety management system.

On 14 October there was no hazardous or other work permits issued for the TAV2 repair and no valves were tagged or locked out by either the chief engineer or third engineer. In fact, there is no evidence to suggest that work permits were routinely issued for steam valve repairs on board *River Embley*.

The JSA required that a blanket be placed over the valve while it was being dismantled. Given that the valve was inverted, rigging a blanket or 'curtain'

protection may not have been practical. The blanket would have been in the way while the engineers removed the valve bonnet retaining nuts. Fitting a blanket covering the TAV2 on 14 October may have deflected some condensate; however it is more probable that it would have had limited effect because the engineers were beneath the valve.

Had the boiler stops and other isolating valves been tagged or locked out, it would not have prevented the flow of condensate from the TAV2, as there was no evidence to suggest that someone inadvertently opened a valve. Similarly the incident would probably have occurred, even if a work permit had been issued. Neither the 'Hazardous work permit', the 'Pipelines and pressure vessels permit' nor the JSA required the TAV2 be open when work started, or that the steam system be allowed to cool or be fully drained before work had started. None of these safety measures had identified all the risks involved in overhauling the TAV2. However, not implementing the basic safety measures contained in the ship's safety management system would generally increase the risk of an accident occurring.

Neither the external AMSA audit on 23 July 2005 nor the internal ship management audit on 19 August 2005 detected that permits were not being used on board *River Embley* for tasks such as steam valve repairs, nor did they highlight that JSAs such as the one titled 'steam valves' were not complete or signed off.

While the purpose of auditing is to identify safety management system breakdowns, such as those noted above, it is also understandable that it is not always possible in the time available to an auditor to look at the entire system. In most instances audits target selected areas throughout a vessel's safety management system. Auditors should, however, ensure that core procedures such as work permits, tag-out systems and safety analysis are thoroughly checked at every audit.

4.8 Resource management

The chief engineer on board *River Embley* at the time of this incident was widely acknowledged as the most senior and experienced engineer in the management company's steam ship fleet. He is highly regarded by his employer and respected by the engineers with whom he sails. In fact he has trained and mentored many of the company's engineers.

While there is no evidence to suggest that he was anything but a knowledgeable and experienced engineer, it is possible that his professional standing with his colleagues was a factor in the incident.

It is possible that the other engineers may have been so respectful and comfortable with the chief engineer's decision making that they could see no reason why they should question, or second guess it. It appears that no one questioned whether the anchorage was the proper place to complete this maintenance task, or whether a work permit should be issued, or indeed whether valves should be tagged or locked out. When the third engineer arrived at the work site, he immediately started to assist the chief engineer. He did not check if the system had drained. He did not check or even ask if the valve they were working on was open or closed. He took no time to assess the situation. He simply assumed that the chief engineer had taken the appropriate precautions.

It is important to note that unlike deck officers, engineers receive no training that would encourage them to question a chief engineer's decisions or actions, and there is no system in place that would encourage them to do so.

It is therefore conceivable that a simple error in judgement by one person, a single person error, was allowed to go unchecked and unquestioned.

It is a STCW95⁴ requirement that today's deck officers are trained in the practices of bridge resource management (BRM)⁵. The concepts of BRM include communications and briefings, how to detect and deal with issues such as an experience gradient⁶, the fostering of an environment that encourages challenges and responses, and the development of short term strategies.

One of the primary aims of bridge resource management is to reduce risks by working as a team and thus minimising the consequences of 'single person' errors. If these principles had been implemented in the engine room on board *River Embley* on 14 October 2005, the incident may have been avoided.

4.9 Emergency response

The response of the ship's crew after the incident was both timely and decisive. The chief engineer was immediately placed under an emergency shower. This was without doubt the correct action. Coupled with this action was the prompt decision to request an emergency helicopter evacuation. This meant the chief engineer was receiving medical attention in the shortest possible time.

The Rockhampton based Capricorn Helicopter Rescue Service, the closest emergency response service to the ship's position, was notified at 1102. The response helicopter took off at 1126 and landed on board the ship at 1206. The helicopter departed the ship at 1236, after the paramedic had assessed the chief engineer's condition and assisted him on board. The helicopter arrived at the Gladstone Hospital helipad at 1248.

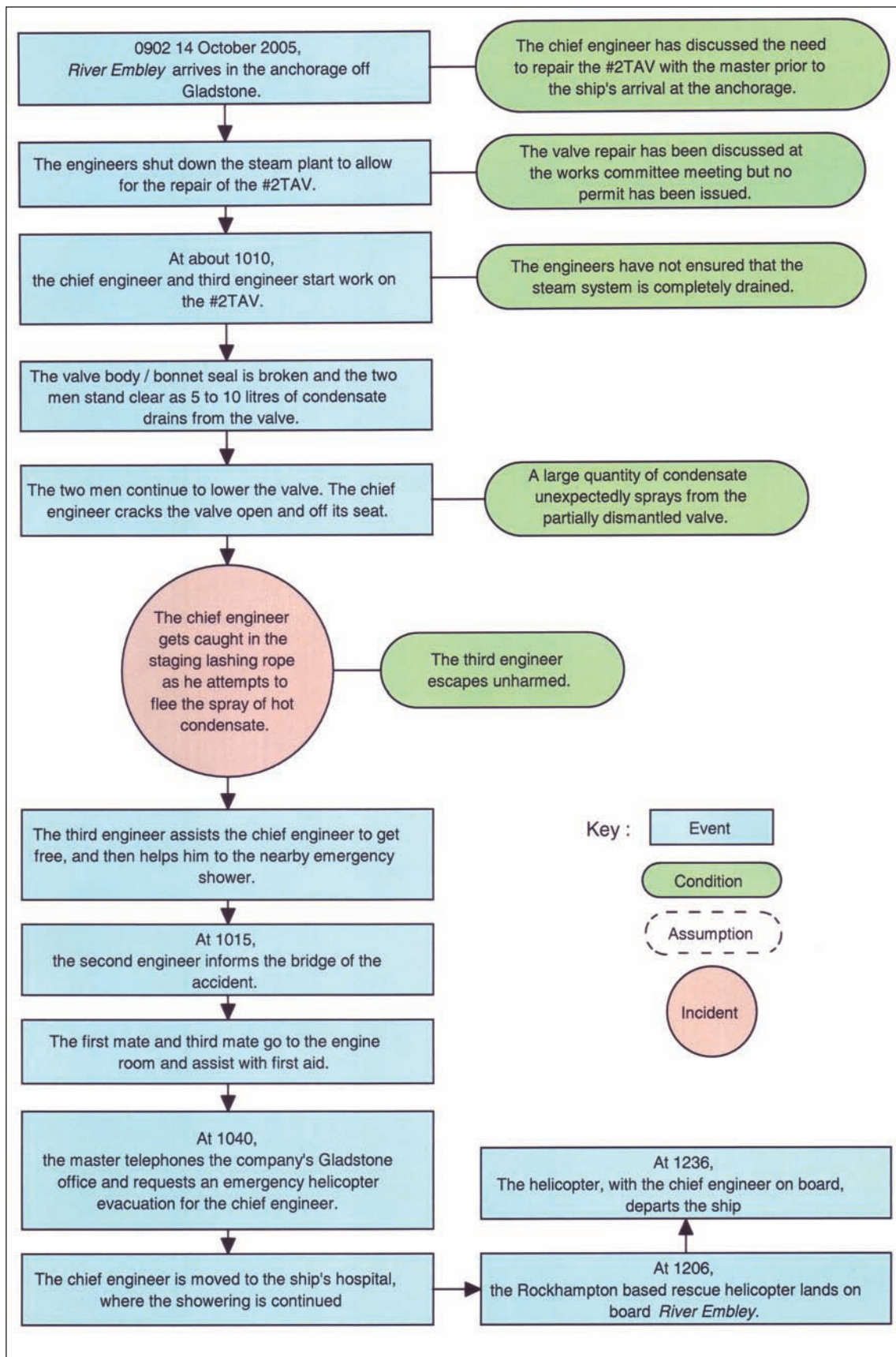
The chief engineer arrived at Gladstone Hospital within about two and a half hours after sustaining his injuries. There is little doubt that the first aid administered and the timely response by all concerned was a factor in limiting the effects of the chief engineer's injuries.

4 Seafarer's Training, Certification and Watchkeeping Code, International Maritime Organization, 1995.

5 Nijjer (2000) defines BRM as: The use and coordination of all the skills and resources available to the bridge team to achieve the established goal of optimum safety and efficiency.

6 A large difference in the level of experience between a senior officer and a junior officer.

Figure 7: Events and causal factors chart



5 CONCLUSIONS

These conclusions identify the different factors that contributed to the accident and should not be read as apportioning blame or liability to any particular individual or organisation.

Based on the available evidence, the following factors are considered to have contributed to the scalding of the chief engineer on board *River Embley* on 14 October 2005.

1. When the TAV2 was cracked open, the condensate trapped in the pipe lines between the TAV2 and the exhaust steam range sprayed from the partially dismantled valve.
2. The chief engineer became entangled in the staging securing rope when he attempted to avoid the hot condensate that unexpectedly sprayed from the valve.
3. Insufficient time was left between when the steam plant was shut down, and the TAV2 was opened up and consequently the exhaust steam system had not completely drained.
4. The engineers did not fully assess the exhaust steam piping system, and the inadequacies in its drain arrangements. They did not take appropriate steps to ensure that the pipe lines on both sides of the TAV2 were fully drained.
5. The control measures outlined in the vessel's safety management system were not implemented on 14 October 2005, and those implemented by the ship's engineers did not adequately protect them.
6. Neither the external audit on 23 July 2005 nor the internal audit on 19 August 2005 detected that permits were not being used on board *River Embley* for tasks such as steam valve repairs, nor did they highlight that JSAs such as the one titled 'steam valves' were not complete or signed off.

It is also considered that:

7. If they had been implemented, the safety management system procedures and associated checklists would not have ensured adequate protection for the engineers working on the steam valve. Therefore the system was not an effective defence.
8. The existence of a sizable experience gradient between the chief engineer and the other engineers, along with a lack of team training, allowed a series of 'single person' errors to go unchecked and unquestioned.
9. The quick action of all concerned in administering first aid and facilitating a timely helicopter evacuation assisted in minimising the effect of the injuries sustained by the chief engineer.

6 RECOMMENDATIONS

MR20060022

ASP Ship Management should review the safety management systems on board *River Embley* and her sister ships to ensure they contain adequate control measures for critical tasks such as a steam valve repair. The review should include all job safety analysis data to ensure that the analysis is complete, reviewed and approved.

MR20060023

Ship owners, managers and auditing authorities should review routine safety management system auditing plans to ensure that procedures and control measures that are critical to personnel safety, such as work permits, tag-out systems and safety analysis, are implemented on board all ships.

MR20060024

Training institutions, regulatory authorities and ship managers should consider the implementation of a form of team resource management training for engineers. This training should be aimed at encouraging the implementation of principles and practices consistent with the STCW95 requirements for BRM training of deck officers.

7 SUBMISSIONS

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

The final draft of this report was sent to *River Embley*'s master, chief engineer, third mate and third engineer, the Australian Maritime Safety Authority and ASP Ship Management.

Submissions were included and/or the text of the report was amended where appropriate.

8 RIVER EMBLEY

IMO Number	8018144
Call sign	VJRY
Flag	Australian
Port of Registry	Sydney
Classification society	Lloyds Register of Shipping (LR)
Ship Type	Bulk carrier
Builder	Mitsubishi Heavy Industries
Year built	1983
Owners	River Embley
Ship managers	ASP Ship Management
Gross tonnage	51 035
Net tonnage	16 346
Deadweight (summer)	76 358 tonnes
Summer draught	12.321 m
Length overall	255 m
Length between perpendiculars	248.01 m
Moulded breadth	35.35 m
Moulded depth	18.29 m
Engine	Mitsubishi MS-21-2 steam turbine
Total power	13 976 kW
Service speed	14.5 knots
Crew	20

Lack of safety measures led to chief engineer's severe burns

An Australian Transport Safety Bureau (ATSB) investigation has found that a lack of hazard awareness and safety control measures led to the chief engineer on board the Australian bulk carrier *River Embley* sustaining burns to 45 percent of his body when he was scalded by hot water that unexpectedly sprayed from a steam valve he and a junior engineer were working on.

On the morning of 14 October 2005 the engineers were working in the engine room while the ship was at anchor off Gladstone. While they were dismantling the turbo alternator exhaust steam valve a thousand litres of pressurised hot water unexpectedly started to spray from the valve and onto the chief engineer standing on staging below.

In an effort to escape the hot water spray the chief engineer tried to jump clear of the staging but became entangled in the securing rope which had formed a barrier.

The ship's crew mounted an immediate first aid response and the master organised a helicopter evacuation. The chief engineer was transported to Gladstone Hospital and later transferred to the Royal Brisbane Hospital intensive care unit.

The report concludes that the engineers did not fully assess the exhaust steam piping system and its drainage arrangements, or allow sufficient time for the exhaust steam system to completely drain before starting to work on the valve.

The ship's work permit system and job safety analysis procedures were not utilised by the engineering crew and deficiencies in safety management were not identified in two audits prior to the accident.

It is also considered that a sizable experience gradient between the chief engineer and the other engineers along with a lack of training allowed a series of 'single person' errors to go unchecked and unquestioned.

The ATSB has made several safety recommendations aimed at preventing further accidents.

