



Auxiliary boiler explosion on board *Saldanha* off Newcastle, 18 November 2008

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ABSTRACT

On 18 November 2008, while the Maltese registered bulk carrier *Saldanha* was anchored off Newcastle, NSW, a ship's engineer was burned when the auxiliary boiler furnace 'flashed back' during a routine boiler oil firing unit burner exchange.

The ATSB investigation into the incident found that the ship's crew were not aware of all of the hazards associated with maintaining the boiler burner; were not aware of previous flashbacks involving similar burners; and were not aware of the appropriate first aid treatment required for burn injuries.

The investigation also found that the safety bulletin that had been previously issued by the manufacturer did not inform operators that the oil firing unit could be modified.

The ATSB has acknowledged the proactive safety action taken by the responsible organisations in relation to the identified safety issues. The ATSB has also issued one safety recommendation and one safety advisory notice.

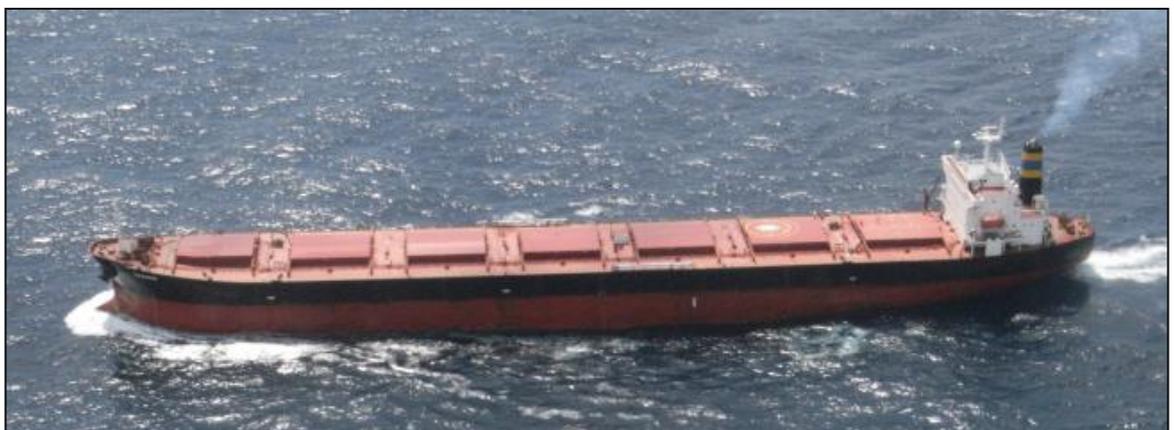
FACTUAL INFORMATION

Saldanha

Saldanha (Figure 1) is a conventional Panamax¹ bulk carrier. At the time of the incident, the ship was owned by Team-up Owning Company, Marshall Islands, managed by Cardiff Marine, Greece, registered in Malta and classed with Nippon Kaiji Kyokai (ClassNK).

The ship was built in 2004 at Okayama, Japan. It has an overall length of 225.0 m, a moulded breadth of 32.3 m, a moulded depth of 19.3 m and a deadweight of 75,707 tonnes at its summer draught of 14.0 m.

Figure 1: *Saldanha*



1 A ship that is limited in size to the dimensions of the Panama Canal.

Propulsive power is provided by a B&W 7S50MC-C single acting, direct reversing, two-stroke diesel engine. The engine develops 8,974 kW at 104 rpm and drives a fixed pitch propeller, giving the ship a service speed of about 14 knots².

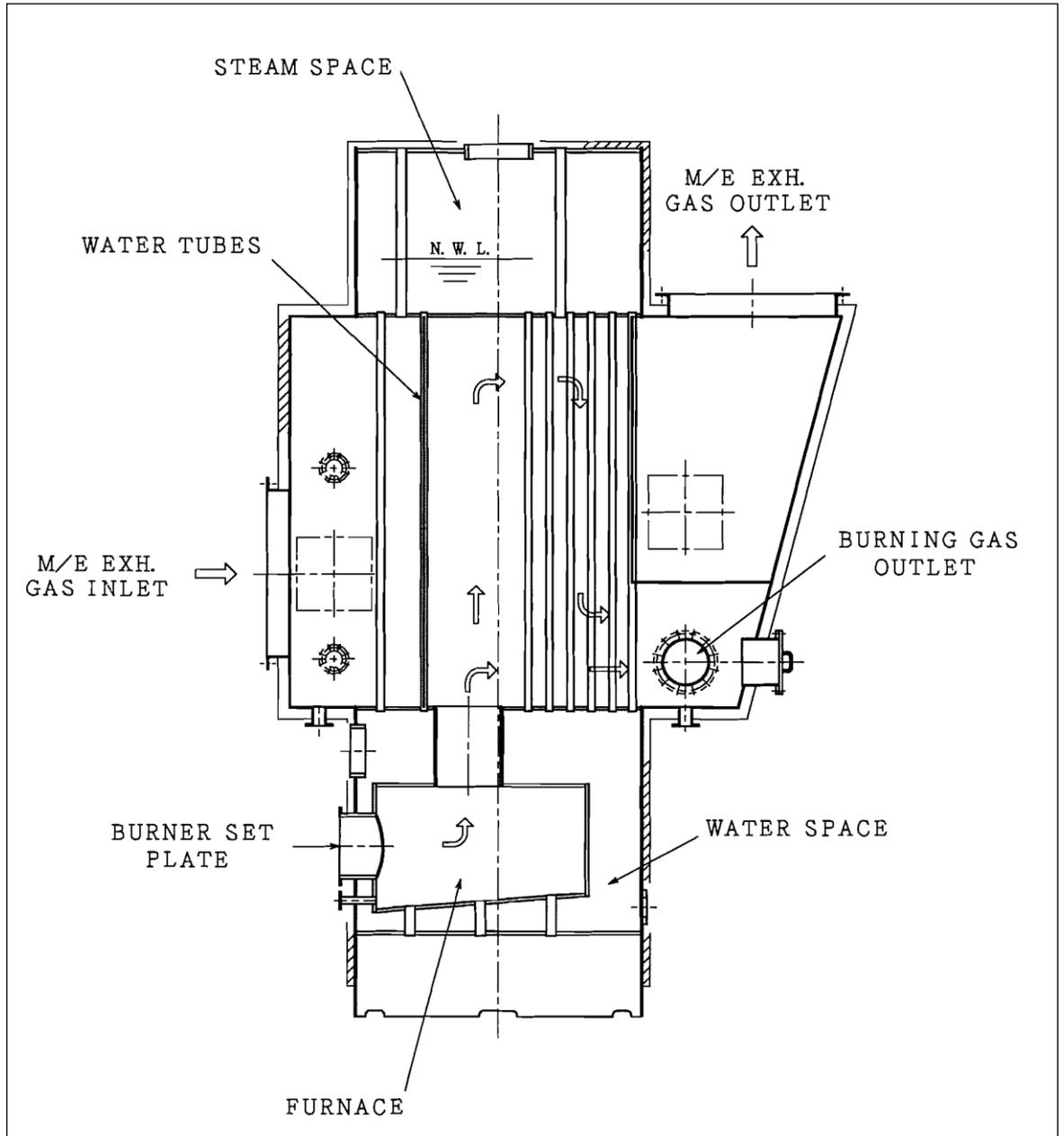
At the time of the incident, *Saldanha* had a crew of 21. The master and the electrician were Romanian nationals and the remaining crew were Filipino nationals.

The master had 17 years of seagoing experience and had been serving as master for 2 years.

The chief engineer had 32 years of seagoing experience and held a chief engineer's licence issued in the Philippines. He joined *Saldanha* for the first time in September 2008.

The third engineer held a third engineer's licence issued in the Philippines. He had 12 years of

Figure 2: Diagram of Osaka OEVC3 boiler



2 One knot, or one nautical mile per hour equals 1.852 kilometres per hour.

seagoing experience and had been serving as a third engineer since 2002. At the time of the incident, he had been on board *Saldanha* for about 11 months.

While *Saldanha* was at sea, the engineers and oilers maintained a traditional 'four on/eight off' watch keeping routine. At anchor, the oilers continued with their watch keeping routine and the engineers worked during normal daylight hours.

The auxiliary boiler

Saldanha was fitted with an Osaka Boiler Mfg Company OEVC3-120/90-19 vertical composite boiler (Figure 2) with a working pressure of 6.9 bar³. The steam produced by the boiler is used on board the ship for the heating/treatment of heavy fuel oil and for general purpose heating.

The upper section of the boiler water space houses the economiser, where the main engine exhaust gases are directed over a bank of water

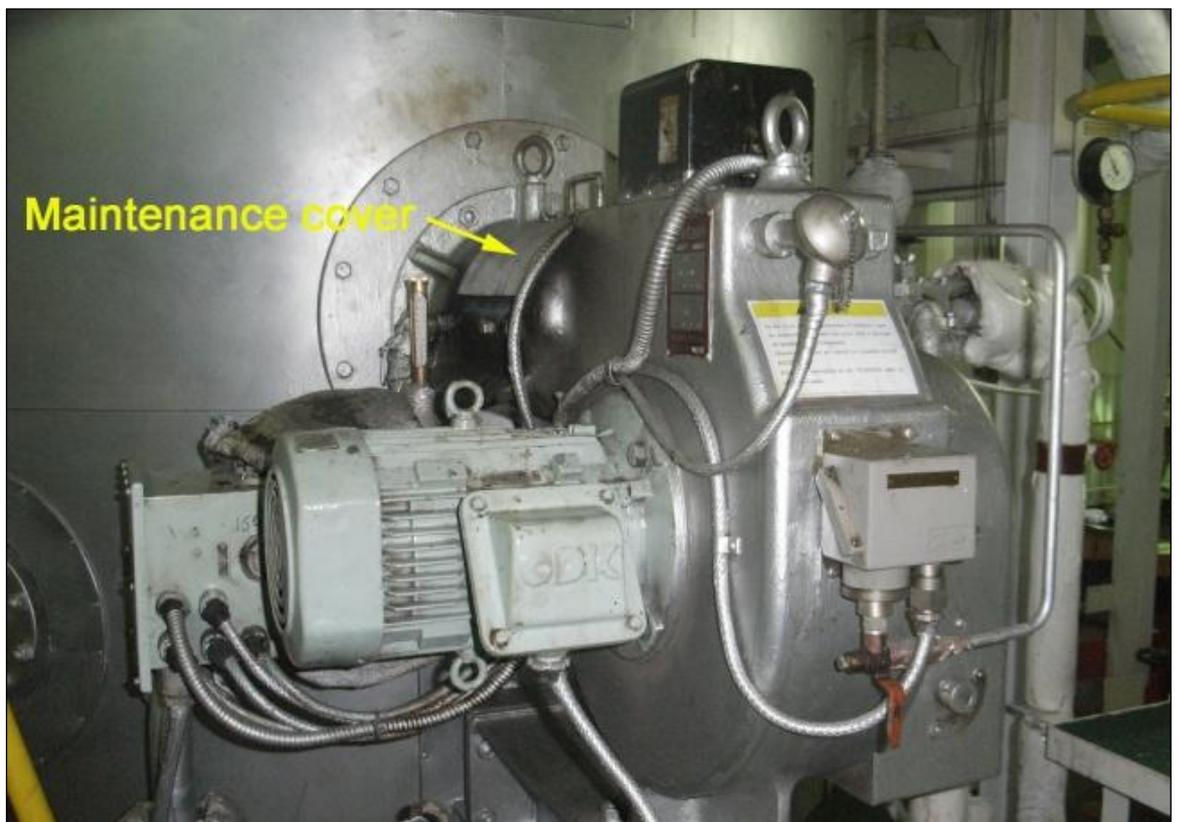
tubes to produce steam. It also houses the smoke box, which has a hot gas inlet from the furnace, another bank of boiler water tubes and a burning gas outlet.

A cylindrical steel furnace lies below the smoke box. The furnace chamber has an opening on one side to which an oil firing unit is fitted. When the oil burner is firing, the flame is directed at the furnace wall opposite the burner opening. The flow of hot gas sweeps the periphery of the cylindrical furnace chamber before rising to the smoke box inlet.

When the ship's main engine is stopped, or is providing insufficient exhaust gas energy to produce enough steam to meet demand, the boiler is fired on heavy fuel oil.

The oil firing unit, model number VJ-140-3, was manufactured by the Volcano Company of Japan (Figure 3). It comprises a fully automatic pressure jet oil burner, integrated with a single electric

Figure 3: Boiler oil firing unit



3 1 bar equals 100 KPa or approximately one atmosphere.

motor driving both the forced draft fan and the fuel oil feed pump. Control of combustion air flow is provided by a single two-position damper on the forced draft fan's air inlet housing.

The oil firing unit may be fired using either diesel or heavy fuel and has an integrated electric fuel heater for use when firing on heavy fuel. The unit's control and monitoring system are located in a cabinet which is mounted adjacent to the boiler.

The burner (Figure 4) is fitted inside the oil firing unit at the boiler furnace opening. The burner consists of an atomiser block, which holds a single fuel nozzle, to which a flame stabilisation ring and a pair of ignition electrodes are attached.

The atomiser block has three fuel line connections; one line is led from a solenoid valve

which supplies the fuel nozzle, and the other two allow fuel circulation through the atomiser block.

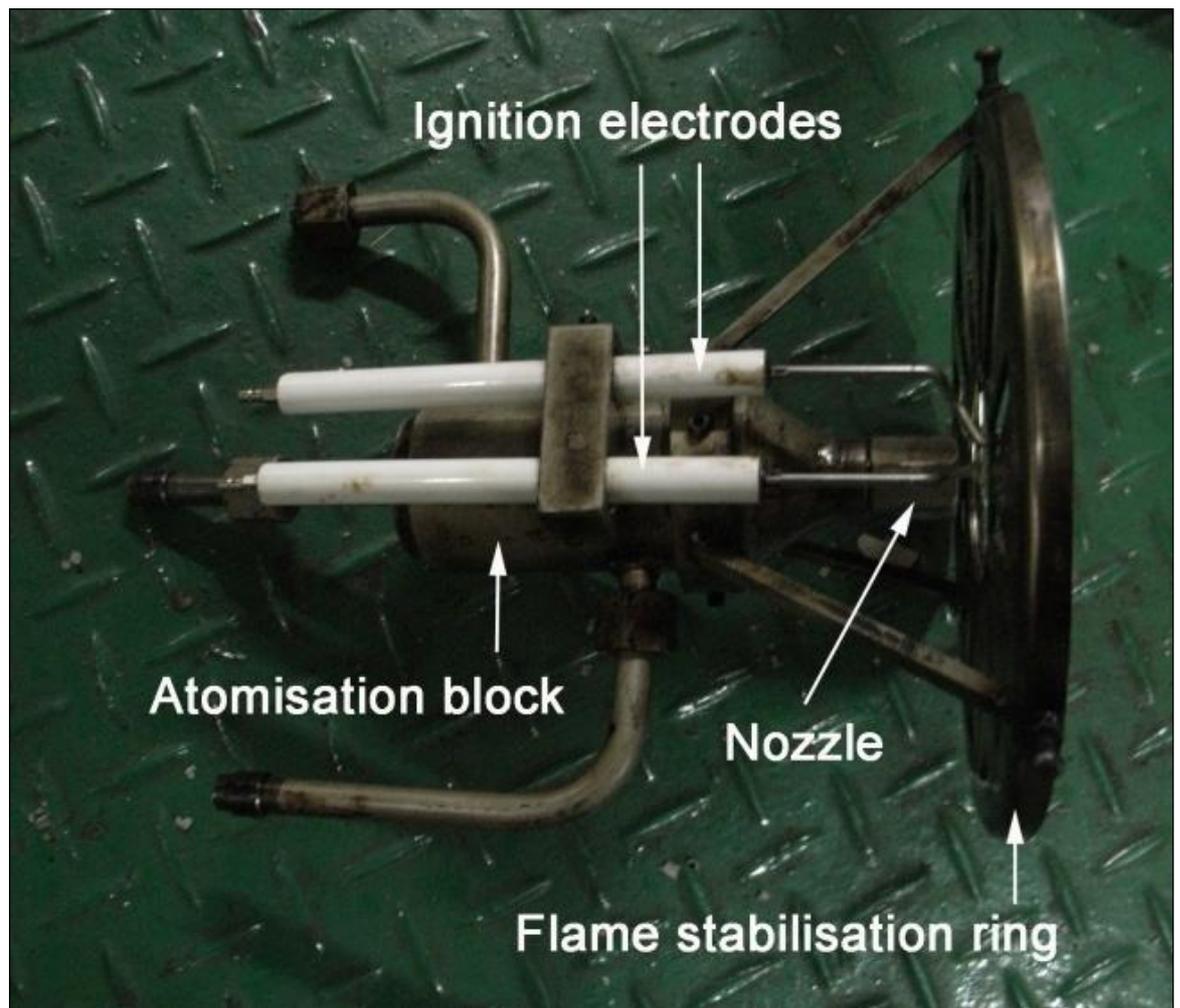
The burner may be removed from the oil firing unit through a maintenance cover at the top of the oil firing unit (Figure 3), after the ignition electrode cables and the three fuel pipes have been disconnected.

The incident

At 2030⁴ on 14 November 2008, *Saldanha* was anchored off Newcastle, NSW, awaiting berth availability to load coal for export. While the ship was at anchor, the crew carried on with their routine watch keeping duties and assigned maintenance tasks.

At 0800 on 18 November, the engineers started work as usual. The second engineer was the duty

Figure 4: Oil firing unit burner



4 All times referred to in this report are local time, Coordinated Universal Time (UTC) + 11 hours..

engineer, so he and the duty oiler started their inspections of the engine room while the other engineers and oilers carried on with maintenance tasks.

The third engineer was overhauling a spare main engine exhaust valve with the assistance of an oiler. The two men carried on with that task throughout the day, stopping for a break at 1000 and for lunch at 1200.

At about 1315, after the third engineer returned from his lunch break, the duty oiler informed him that the auxiliary boiler had just alarmed as a result of a burner misfire. The third engineer thought that the boiler burner was probably dirty and would need to be replaced with the clean spare unit.

At 1500, when the engineers and oilers met in the control room for their afternoon tea break, the third engineer spoke to the second engineer about the boiler burner misfire. The two men agreed that the burner would need replacement and that the third engineer should complete the task after the tea break.

At 1530, the third engineer prepared the tools he would need. He also put on a pair of leather gloves and safety goggles.

The boiler burner was still firing, so the third engineer changed it over to diesel oil so that the heavy fuel oil would be flushed through the fuel lines. He then waited until the burner automatically cut out when the boiler pressure reached 6.9 bar.

The boiler furnace was then automatically purged by the forced draft fan for 1 minute as part of the shutdown process. When the purge cycle had completed, the third engineer switched the boiler control select switch to the 'off' position and closed the fuel oil supply valves.

The third engineer opened the oil firing unit maintenance cover and disconnected the ignition electrode cables. He then loosened the three fuel pipe connections on the atomiser block and a small amount of fuel drained from the fuel lines.

A few seconds later, at 1606, while the third engineer was pushing on the burner to disconnect it from the fuel lines, there was an explosion (flashback) from the boiler furnace.

The flames from the flashback briefly engulfed the third engineer, who turned and ran from the boiler, covering his face with his hands. The flames also set off the engine room fire alarm.

The third engineer checked around the boiler, looking for signs of fire. When he saw that there was no fire, he refitted the maintenance cover and then ran to the engine control room for help.

He was yelling and gesturing that his face and neck had been burned. Ointment was put on his burns and then one of the oilers took him to the ship's hospital.

The master, who was on the bridge at the time, was notified of the incident. He checked on the third engineer's condition but was not sure how to best treat his burns, so he made a satellite telephone call to the International Radio Medical Centre to seek advice.

The master returned to the hospital about 10 minutes later and washed the third engineer's burns with cool water. When the master considered that the burns had cooled sufficiently, he covered them with gauze.

The master thought that the third engineer probably needed further medical treatment, so he telephoned the ship's manager and notified him of the incident. He also telephoned the ship's agent in Newcastle and requested that a medical evacuation be arranged.

In the meantime, the chief engineer and the second engineer inspected the boiler and found nothing unusual. The second engineer then fitted the clean burner unit without incident. When he had finished, he opened the fuel supply valves, switched the oil firing control unit 'on' and the burner fired normally.

At about 1900, a rescue helicopter landed on board the ship. Paramedics from the helicopter assessed the third engineer's injuries and helped him on board. The helicopter then departed the ship.

The third engineer was taken to the John Hunter Hospital in Newcastle, where he was admitted for treatment to his injuries. He was discharged 2 days later and taken to Sydney where he received outpatient medical treatment from the Royal North Shore Hospital Burns Unit while awaiting repatriation to the Philippines.

ANALYSIS

The flashback

When the oil firing unit was shut down, and the automatic purge cycle was completed, there would have been no flow of air through the furnace until the third engineer removed the burner maintenance cover. With the maintenance cover removed, the air flow through the furnace was dependent upon the ambient pressure in the engine room and the natural updraught within the boiler due to the hot exhaust gas uptakes. As a result, the air flow through the furnace was limited; probably passing directly from the oil firing unit opening to the smoke box inlet, leaving areas adjacent to the furnace floor and walls relatively unswept (Figure 2).

When the third engineer loosened the fuel connections, the diesel oil that drained out of the lines was probably swept into the boiler furnace by the air flowing into the furnace through the maintenance opening.

It is likely that there was sufficient residual heat in the furnace to vaporise the fuel. When the fuel vapour/air mixture inside the furnace reached its flammable range⁵, it was ignited by a hot surface within the furnace, or by smouldering fuel/carbon residue on the furnace floor.

Once the fuel vapours were ignited, the furnace pressure rapidly increased until the pressure was sufficient to push a flame front out of the furnace, through the oil firing unit maintenance opening.

Servicing the burner

The ship's records indicated that it was not unusual for *Saldanha's* boiler to misfire because of a build-up of carbon on the flame stabilisation ring. During periods when the boiler burner was operating, it was normal practice for it to be exchanged with a clean replacement unit once or twice a week.

Saldanha's crew had identified a number of hazards associated with servicing the boiler burner. Consequently, they had identified the need to use appropriate personal protective

equipment (gloves and goggles) and to purge the furnace before servicing the burner.

While purging of the boiler furnace prior to opening the oil firing unit is a basic safety precaution, in some instances, this precaution alone may not be enough to prevent a flashback.

If there have been a number of unsuccessful attempts to ignite the burner just before it is removed, or fuel drains from the burner fuel connections and is swept into the furnace, liquid fuel may be lying in the furnace even after a lengthy purge. Hence it is essential to allow the furnace to cool sufficiently before it is opened.

The ship's crew had not identified the need to allow the furnace to cool sufficiently before the maintenance cover was opened. While, the ship's planned maintenance system referred to the manufacturer's instruction manual, which described how to service the burner, neither the ship's operator nor its crew had appropriately analysed the risks associated with the task and developed a ship specific work instruction that identified all of the necessary safety precautions to be followed.

As a result, on each occasion that *Saldanha's* engineers opened the oil firing unit maintenance cover, shortly after the burner had stopped firing, they were exposed to the risk of a boiler flashback similar to the one that occurred on 18 November 2008.

Previous incidents

There has been a number of similar previous flashback incidents on board ships fitted with Osaka OEVC type composite boilers and Volcano VJ type burners.

On 29 April 2001, the bulk carrier *Alam Mesra* experienced a series of boiler explosions similar to those which occurred on board *Saldanha*. After a succession of burner flame failures, the engineers disconnected the burner and removed it from the oil firing unit. While they were in the workshop, cleaning the burner, they heard an explosion from the boiler. They went to investigate and, while they were examining the boiler, there was a succession of flashbacks from the boiler furnace. Two men were burned as a result of the incident.

⁵ The flammable range includes all concentrations of flammable vapour or gas in air, in which a flash will occur or a flame will travel if the mixture is ignited.

On 17 May 2003, a series of boiler explosions occurred on board the bulk carrier *Medi Monaco*⁶. After a number of burner flame failures, the third engineer decided to clean the burner. While he was in the process of removing the burner, there was a flashback from the boiler furnace. The third engineer suffered severe burns to his face and upper body. Two other engineers went to the boiler to see what had happened and as they were inspecting the burner, there was a second flashback. Both men sustained burns to their faces.

On 2 April 2007, a series of boiler explosions occurred onboard the bulk carrier *Shirane*⁷. An engineer was checking the operation of the boiler after he had fitted a clean spare burner, but it failed to ignite. A few moments later, while he was removing the burner to inspect it, there was a flashback from the boiler furnace. The engineer was severely burned by the flashback. After purging the boiler furnace for about an hour, the other engineers removed the burner to inspect it. A few moments later, there was a flashback from the boiler furnace. The chief engineer, the second engineer and a fitter were burned by the flashback.

The cause of these incidents have been attributed to either the leakage of fuel from the burner fuel connections during maintenance or the depositing of fuel in the furnace by repeated burner misfires. In each case, it is likely that despite furnace purging, in accordance with normally safe boiler practice, there was still sufficient heat left in the furnace to vaporise and then ignite the fuel.

The ATSB investigation into the *Shirane* incident found that:

The ship's crew were not aware of similar previous flashbacks involving Osaka OEVC2 boilers and they were not aware of all of the hazards associated with servicing the boiler burner.

As a result of this finding, the Osaka Boiler Mfg Company, in consultation with the Volcano Company, developed a safety bulletin and caution plates that could be fitted to VJ type burners and

their control panels. The bulletin was supplied to all operators of ships fitted with VJ type burners.

Shirane's operators went one step further than just posting a set of caution plates and safety bulletins; they modified the oil firing unit by installing a Volcano VJP type burner. The main change in the burner design is that the atomiser block is replaced and a diesel pilot burner is added.

The Volcano Company safety bulletin

The Volcano Company safety bulletin and the associated caution plates were forwarded to operators of Osaka OEVC boilers fitted with VJ type burners, including Cardiff Marine (*Saldanha*'s managers).

On 9 May 2008, Cardiff Marine forwarded the safety bulletin to *Saldanha*'s master, via email. The caution plates and a hard copy of the safety bulletin were also mailed to the ship, arriving on board on 13 June 2008.

The 9 May email to the ship's master stated;

For this type of burner maker Volcano has issued update safety precautions after an incident on other vessel...

Please find attached relevant tif image with precaution notes, dwgs [sic] and brief description of incident, root cause and findings by maker Volcano. Please print out attachment and insert in suitable position in the burner's instruction-maintenance manual.

The caution plates were attached to *Saldanha*'s boiler oil firing unit and its control panel soon after they arrived on board and, when the ATSB investigators arrived on board the ship, a copy of the safety bulletin was found attached to the front of the Volcano VJ burner instruction-maintenance manual. However, the print date of the emailed safety bulletin (noted at the top of the page) was 20/11/2008, 2 days after the third engineer was injured. This suggests that the safety bulletin had not been attached to the manual prior to the incident.

6 ATSB Transport Safety Report No.194.

7 ATSB Transport Safety Report No.238.

The engine room crew were not aware of the critical safety precautions contained in the safety bulletin. Although the first line of the newly edited safety precautions stated 'don't attempt to relight the burner without eliminating the cause of ignition failure', it was routine practice on board *Saldanha* for the boiler to be immediately reset following a flame failure.

The flame failure alarm had sounded at least 32 times between 2030 on 14 November, when the ship was anchored off Newcastle, and 1545 on 18 November, when the third engineer started removing the burner. On each occasion the boiler was reset by the duty oiler within a minute.

The third engineer was assigned to carry out routine auxiliary boiler maintenance. However, at interview, he stated that he had not seen the safety bulletin and, consequently, was not aware of any previous flashback incidents involving similar boilers, or the precautions that the manufacturer suggested should be followed.

While *Saldanha's* operators forwarded the safety bulletin to the ship, they did not incorporate the information it contained into a fleet safety circular or a ship-specific work instruction. Furthermore, the ship's senior officers did not ensure that the critical safety information contained in the safety bulletin was passed on to those responsible for operating and maintaining the boiler; and the engineers and oilers did not operate the boiler in accordance with the clearly posted warnings.

Had the engineers and oilers been aware of the information contained in the safety bulletin, or paid appropriate attention to the caution plates, they would have been armed with a set of defences against a previously identified hazard.

While such defences mitigate the risk, they do not remove it. Hence, the safety bulletin probably did not go far enough. It warned operators of an identified risk associated with the VJ type burner and provided them with a set of recommended safety precautions. However, it did not inform them that the VJ burner could be replaced with a VJP burner (a similar burner fitted with a diesel pilot burner), or recommend that existing oil firing units could be modified.

First aid

On 18 November 2008, the third engineer went to the engine control room, where his burns were

treated with burn ointment. He was then taken to the ship's hospital where the master assessed his condition and sought medical advice. The master then cooled the third engineer's burns with water.

With reference to the first aid treatment of heat burns, St John Ambulance Australia states⁸:

1. Remove the casualty from danger.
2. Cool the burnt area.
 - Hold burnt area under cold running water – up to 20 minutes.
 - If a chemical burn, run cold water over burnt area – at least 20 minutes.
 - If a bitumen burn, run cold water over burnt area for 30 minutes.
 - If burn is to eyes, flush eyes with water for 20 minutes.
3. Remove any clothing or jewellery from the burnt area (unless it is sticking to the burn).
4. Place a sterile, non-sticking dressing over the burn.
5. Calm the casualty.
6. Seek medical assistance.

Warning

1. Do not apply lotions, ointment or fat to burn.
2. Do not touch the injured area or burst any blisters.
3. Do not remove anything sticking to the burn.
4. If the burn is large or deep manage for shock.

Guidance for the first aid treatment of burns contained in *The Ship Captains Medical Guide*⁹ was similar to that provided by St John Ambulance Australia.

While the master's decision to seek medical advice was probably wise, the STCW Code¹⁰ states that all seafarers are required to demonstrate a basic understanding of first aid.

⁸ A quick guide to first aid/burns, St John Ambulance, Australia, website - www.stjohn.org.au

⁹ *The Ship Captains Medical Guide*, 22nd Edition 1999, Maritime and Coastguard Agency, pg 17.

¹⁰ Seafarers Training, Certification and Watchkeeping Code, Section A-VI/4, International Maritime Organization.

The actions of the master and crew on board *Saldanha* on 18 November 2008 indicate that they did not possess an appropriate level of understanding of the first aid treatment of burns. Had the third engineer's burns been cooled with running water immediately after he was burned, rather than applying burn ointment, the adverse effects of the burns may have been reduced.

FINDINGS

From the evidence available, the following findings are made with respect to the auxiliary boiler flashback on board *Saldanha* on 18 November 2008 and should not be read as apportioning blame or liability to any particular organisation or individual.

Contributing safety factors

- When the third engineer loosened the burner fuel connections, a small amount of diesel oil drained out of the lines. It is likely that the diesel oil was then swept into the boiler furnace by the air flowing into the furnace through the burner's open maintenance cover.
- The diesel oil was probably vaporised when it was heated by hot surfaces within the boiler furnace or by smouldering fuel/carbon residue on the furnace floor.
- The fuel vapours were probably ignited by a hot surface within the furnace or by smouldering fuel/carbon residue on the furnace floor.
- *Saldanha's* watch keeping engineers and oilers were not aware of any similar previous flashbacks involving Volcano VJ type burners and they were not aware of all of the hazards associated with operating and maintaining the burner. *[Safety issue]*
- While the Volcano Company safety bulletin warned of the dangers associated with servicing the VJ type burner, it did not inform operators that the burner could be replaced with a VJP burner (a similar burner fitted with a diesel pilot burner), or recommend that existing oil firing units could be modified. *[Safety issue]*

- *Saldanha's* master and crew were not aware of the appropriate first aid treatment required for burn injuries. As a result, the third engineer was not immediately provided with appropriate first aid treatment. *[Safety issue]*

SAFETY ACTION

The safety issues identified in 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.

Cardiff Marine

On board understanding of safety bulletin

Safety Issue

Saldanha's watch keeping engineers and oilers were not aware of any similar previous flashbacks involving Volcano VJ type burners and they were not aware of all of the hazards associated with operating and maintaining the burner.

Action taken by Cardiff Marine MO-2008-010-NSA-038

Cardiff Marine has advised the ATSB that the boiler's instruction manual and the relevant maker's safety bulletin have been reviewed on board *Saldanha* and discussed during safety meetings.

A fleet safety bulletin was issued in order to communicate the incident to all ships under the company's management and an extra warning was sent to all ship's fitted with VJ type burners.

The company has confirmed that chief engineers have trained engineering crews on the procedures and precautions to be taken when servicing the burner.

The company's training officer agenda has been amended to include verification of circulation, understanding and compliance with fleet safety circulars and bulletins.

The company also stated that it is in the process of investigating the possibility of modifying *Saldanha's* oil firing unit.

ATSB assessment of the action

The ATSB acknowledges the actions taken by Cardiff Marine to address this safety issue.

Volcano Company

Inadequate information in safety bulletin

Safety Issue

While the Volcano Company safety bulletin warned of the dangers associated with servicing the VJ type burner, it did not inform operators that the burner could be replaced with a VJP burner (a similar burner fitted with a diesel pilot burner), or recommend that existing oil firing units could be modified.

ATSB safety recommendation MO-2008-010-SR-039

The ATSB recommends that the Volcano Company takes safety action to address this safety issue.

Flag States, owners, operators and masters

Poor first aid knowledge

Safety Issue

Saldanha's master and crew were not aware of the appropriate first aid treatment required for burn injuries. As a result, the third engineer was not immediately provided with appropriate first aid.

Action taken by Cardiff Marine MO-2008-010-NSA-040

Cardiff Marine has advised the ATSB that the company has amended its training officer agenda to include the verification of shipboard first aid

skills and where necessary to carry out on board first aid training.

ATSB assessment of the action

The ATSB acknowledges the actions taken by Cardiff Marine to address this safety issue.

ATSB safety advisory notice MO-2008-010-SAN-041

The ATSB advises that flag States, owners, operators and masters should consider the safety implications of this safety issue and take action where considered appropriate.

SOURCES AND SUBMISSIONS

Sources of Information

Saldanha's master and crew

Cardiff Marine

Osaka Boiler Mfg Company

Volcano Company

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 Australian Maritime Safety Authority, the Malta Maritime Authority, Cardiff Marine, the Osaka Boiler Company, the Volcano Company and *Saldanha's* master, chief engineer and third engineer.

Submissions were received from the Australian Maritime Safety Authority, the Malta Maritime Authority, Cardiff Marine, the Osaka Boiler Company, the Volcano Company and *Saldanha's* third engineer.