Australian Government

Australian Transport Safety Bureau

ATSB TRANSPORT SAFETY INVESTIGATION REPORT
Marine Occurrence Investigation No. 236
Final

Independent investigation into the engine room fire on board the Bahamas registered general cargo ship

Baltimar Boreas

off Newcastle, New South Wales
9 February 2007

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Independent investigation into the engine room fire on board the Bahamas registered general cargo ship *Baltimar Boreas* off Newcastle, New South Wales on 9 February 2007.

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Abstract

At 0250 on 9 February 2007, about four hours after the Bahamas registered general cargo ship *Baltimar Boreas* sailed from Newcastle, the ship's fire detection system indicated a fire in the engine room. The second engineer investigated and found that number three diesel generator was on fire. He raised the alarm and discharged a portable extinguisher towards the fire before retreating from the engine room.

The crew mustered and operated the engine room oil tank quick closing valve system. All engine room ventilators, except those at the top of the funnel, were closed. At 0305, the engine room Halon fixed fire extinguishing system was operated and, soon after, the master made a distress call. At 0340, the crew determined that the fire had been extinguished. At 0351, the master cancelled the distress message.

By 0640, the chief engineer had concluded that it was impossible to supply power to the main switchboard due to the burnt electrical cables above the fire damaged generator. The ship was disabled but in no immediate danger and waited for a tug responding to the distress call to arrive.

By 1030, *Baltimar Boreas* was under tow and heading towards Newcastle. At 1920, the ship berthed in the port where its cargo was discharged.

At 1615 on 10 March, after repairs had been completed and its cargo reloaded, the ship sailed from Newcastle to continue its voyage.

The report issues a number of recommendations and safety advisory notices with the aim of preventing further incidents of this type.

THE AUSTRALIAN TRANSPORT SAFETY BUREAU

The Australian Transport Safety Bureau (ATSB) is an operationally independent multi-modal Bureau within the Australian Government Department of Infrastructure, Transport, Regional Development and Local Government. 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.

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 enhance safety. To reduce safety-related risk, ATSB investigations determine and communicate the safety factors related to the transport safety matter being investigated.

It is not the object of an investigation to determine blame or liability. However, 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 proactively initiate safety action rather than release formal recommendations. However, depending on the level of risk associated with a safety issue and the extent of corrective action undertaken by the relevant organisation, a recommendation may be issued either during or at the end of an investigation.

The ATSB has decided that when safety recommendations are issued, they will focus on clearly describing the safety issue of concern, rather than providing instructions or opinions on the method of corrective action. As with equivalent overseas organisations, the ATSB has no power to implement its recommendations. It is a matter for the body to which an ATSB recommendation is directed (for example the relevant regulator in consultation with industry) to assess the costs and benefits of any particular means of addressing a safety issue.

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, risk controls and organisational influences.

Contributing safety factor: a safety factor that, if it had not occurred or existed at the relevant time, 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.

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.

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

- **Critical safety issue**: associated with an intolerable level of risk.
- **Significant safety issue**: associated with a risk level regarded as acceptable only if it is kept as low as reasonably practicable.
- **Minor safety issue**: associated with a broadly acceptable level of risk.

EXECUTIVE SUMMARY

At 2305[1] on 8 February 2007, the Bahamas registered general cargo ship *Baltimar Boreas* sailed from Newcastle, New South Wales. The ship was bound for Papua New Guinea carrying cargo for use in the mining industry. The cargo included 45 containers of ammonium nitrate, commonly used as an industrial explosive.

At 0250 on 9 February, the ship's fire detection system indicated a fire in the engine room. The second engineer investigated and found that the number three diesel generator was on fire. He raised the alarm and discharged a portable extinguisher towards the large fire before retreating. He stopped the engine room ventilation fans on his way out of the engine room.

The crew mustered and operated the engine room oil tank quick closing valve system. All engine room ventilators, except the vents at the top of the funnel, were closed. The thick black smoke and sparks issuing from the funnel vents prevented the crew from accessing them. The master, mindful of the explosive cargo on deck, quickly decided to operate the engine room Halon fixed fire extinguishing system (Halon system) in an attempt to contain the fire.

At 0305, all of the crew had been accounted for and the Halon system was operated. The master's distress message, sent soon afterwards, was received by authorities ashore who began coordinating a response to assist. The crew started the emergency generator and the fire pump and began boundary cooling the engine room.

At 0320, a two-man team wearing self contained breathing apparatus (BA) and equipped with portable fire extinguishers entered the engine room. They discharged the extinguishers at spot fires and exited the smoke filled space quickly. At 0330, they re-entered after the volume of smoke issuing from the funnel vents had diminished. At 0340, the BA team exited the engine room and reported that the fire had been extinguished.

At 0351, the master cancelled the distress message. A ship that had responded to the distress call remained standing by and a police vessel and a tug from Newcastle with fire fighting capability were already en route to assist *Baltimar Boreas*.

At 0410, the BA team re-entered the engine room and again used portable extinguishers on hot spots. The ventilators were then opened and at 0505, after the smoke had cleared, the chief engineer and three crew members entered the engine room without BA.

By 0640, the chief engineer concluded that it was impossible to power the main switchboard. He had restarted the number two generator but the ship's electrical system was too badly damaged. The master reported the situation to the ship's managers. *Baltimar Boreas* was in no immediate danger of drifting closer to the coast and the tug *Wickham* from Newcastle was en route to its position. The police vessel had arrived and the ship which had stood by to assist was released to continue its voyage.

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1 All times referred to in this report are local time, Coordinated Universal Time (UTC) + 11 hours, except the local times from 9 April 2007 which are UTC + 10 hours.

At 1030, the tug *Wickham* started to tow the disabled ship back to Newcastle. At 1635, a pilot boarded the ship off Newcastle and it was berthed in the port to firstly discharge the ammonium nitrate containers.

By 1233 on 10 February, the containers had been discharged and the ship was then towed to a lay by berth for repairs to its electrical system.

On 10 March, following the completion of extensive repairs, *Baltimar Boreas* was shifted, under its own power, to the berth for reloading the ammonium nitrate cargo. At 1615, after reloading its cargo, the ship sailed again for Papua New Guinea.

The investigation found that diesel oil leaking from a failed flexible fuel hose on *Baltimar Boreas*'s number three generator had ignited on a very hot surface of the generator's engine. Long term damage due to rubbing and chafing contributed to the failure of the fuel hose.

The investigation identified a number of safety issues. Maintenance of the generator flexible fuel hoses was inadequate, inappropriate temporary repairs had been made and hoses longer than those specified by the generator manufacturer had been used. The poor condition of a number of fuel hoses due to long term wear had not been noted during surveys, audits and inspections in the past. Neither the generator manufacturer's instruction book nor the ship's safety management system provided guidance for the maintenance or replacement of the hoses.

Furthermore, the designed arrangement of the generator flexible fuel hoses was not in accordance with International Maritime Organization guidelines. A number of hoses were not as short as practicable and their use was not limited to only those positions or locations where it was necessary to accommodate relative movement between engine components.

With regard to fighting the fire, it was found that *Baltimar Boreas*'s funnel ventilators could not be closed and they did not comply with the intent of the relevant provisions of international regulations. The engine room was entered too soon after the release of the Halon and, in this regard, the master and crew were not aware of the guidance provided in the Halon system's instruction book on board the ship.

At the time of the fire, there was no dedicated lookout on the ship's bridge. The higher navigational risks when navigating coastal waters in the hours of darkness were further increased when the second mate left the bridge unattended to investigate the fire alarm. Not only was this inconsistent with sound bridge watch-keeping practice, it also contravened the international collision prevention regulations.

In addition to the safety issues, the investigation found that:

- The initial response by the ship's master and crew, and the actions of the second engineer in particular, resulted in the fire being extinguished quickly.
- The response to the incident and its subsequent management by authorities ashore was timely, well managed and appropriate.

1 FACTUAL INFORMATION

1.1 *Baltimar Boreas*

Baltimar Boreas is a Bahamas registered general cargo ship (Figure 1). The ship is owned by Superseven Shipping, Bahamas, and managed by Baltimar A/S, Denmark.

The ship was built in 1989 by Zhonghua Shipyard, China and is classed with Lloyd's Register (LR). It has an overall length of 91.30 m, a moulded breadth of 14.71 m and a depth of 7.62 m. At a summer draught of 4.99 m, the ship has a deadweight of 3188 tonnes.

Figure 1: *Baltimar Boreas* in Newcastle harbour

Baltimar Boreas has a single cargo hold and two deck cranes located forward of the accommodation superstructure. The ship can carry containerised and other general cargo and has a capacity of 256 TEU[2].

Propulsive power is provided by a single MAN B&W 4L35MCE four cylinder, single acting, two-stroke diesel engine developing 1692 kW. The main engine drives a fixed pitch propeller which gives the ship a service speed of 12.5 knots[3]. The LR class notations of +LMC and UMS are assigned to the ship's machinery[4].

The ship's navigation bridge (bridge) is equipped with navigational equipment consistent with SOLAS[5] requirements. The global maritime distress and safety system (GMDSS) communication equipment is also located on the bridge. In

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

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

4 The +LMC notation indicates that the propelling and essential auxiliary machinery is acceptable to LR and UMS indicates that the ship can be operated with its machinery spaces periodically unattended.

5 The International Convention for the Safety of Life at Sea, 1974, as amended.

addition to two very high frequency (VHF) radios, the equipment includes two satellite communications (Inmarsat-C) terminals.

From September 2006, *Baltimar Boreas* had been chartered by Ok Tedi Mining, Papua New Guinea (PNG). The ship mainly carried cargoes from Australia for use in the PNG mining industry.

The ship's crew of 10 consisted of the master, two mates, two engineers, three able seamen, a fitter and a cook. The master was Ukranian while the remaining crew were Filipino nationals. The two mates kept a watch-keeping routine of six hours on and six hours off. At sea, the master assisted them by keeping watch from 0800 to 1200. The two engineers worked in the engine room during normal daytime working hours with one of them on call at other times for UMS operation.

The master started his seagoing career in 1976 and attended a maritime college in Latvia. He held unrestricted qualifications for a master and had sailed as master for the previous seven years on different types of ships. He had been employed by the ship's managers for the previous four years and had joined *Baltimar Boreas*, for the first time, four months before the incident.

The chief mate started his seagoing career in 1986 and held qualifications for a master issued in the Philippines. He had sailed as chief mate for the previous eight years and had been on board the ship for 10 months.

The second mate had been at sea since 1979 and held qualifications for his rank issued in the Philippines. He had sailed as second mate for 13 years, the last six with the ship's managers. He had been on board the ship for more than six months.

The chief engineer started his seagoing career in 1975. He held qualifications for a chief engineer issued in the Philippines and had sailed at that rank for the previous 10 years. He had joined *Baltimar Boreas* in Newcastle two days before the incident for his first assignment with the ship's managers.

The second engineer had been at sea since 1974. He had sailed as second engineer for nine years and held qualifications for his rank issued in the Philippines. He had been on board the ship for 10 months.

1.2 Diesel generators

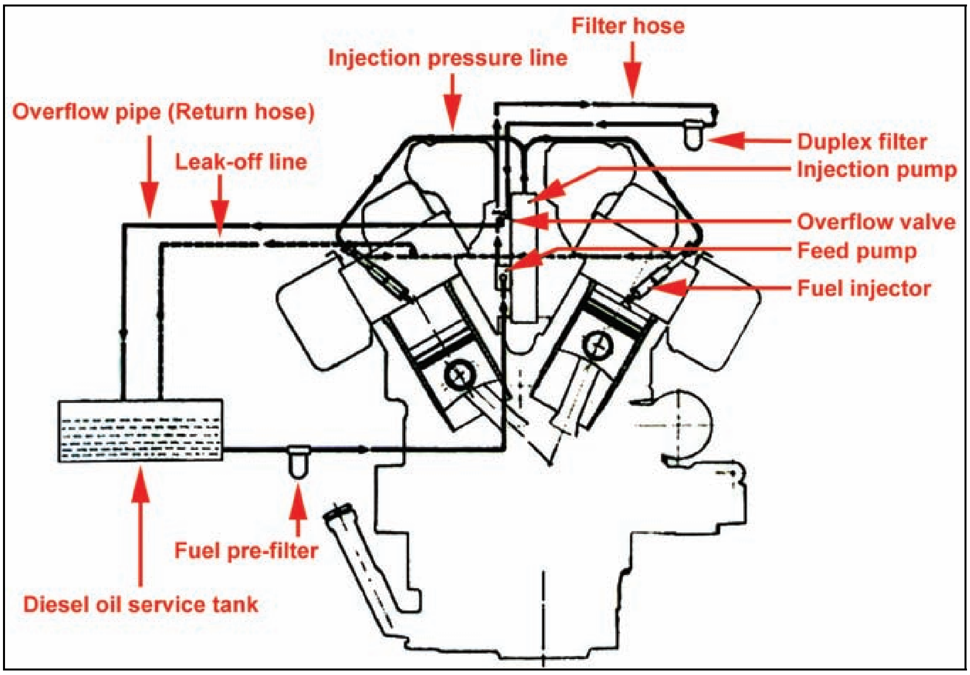
Baltimar Boreas's electrical power is provided by three electrical generators, each of which is driven by a MWM (Motoren-Werke Mannheim) TBD-234 V8 turbocharged eight cylinder diesel engine (diesel generator) developing 212 kW (Figure 2).

The diesel generator fuel system (Figure 3) includes a feed pump to supply marine diesel oil from the service tank. Fuel at low pressure is then supplied via flexible pipes (hoses) and a duplex filter to the fuel injection pump. To keep the injection pump cool, more fuel than is required for injection purposes is supplied with the surplus fuel returning to the service tank via an overflow valve and hoses. All of the system's low pressure fuel lines are hoses with a braided wire outer layer and an internal fuel resistant rubber hose.

The high pressure side of the generator fuel system consists of solid drawn steel pipes. The injection pump supplies fuel via these high pressure pipes to each cylinder's fuel injector.

Figure 2: Number two diesel generator

Figure 3: Generator fuel system



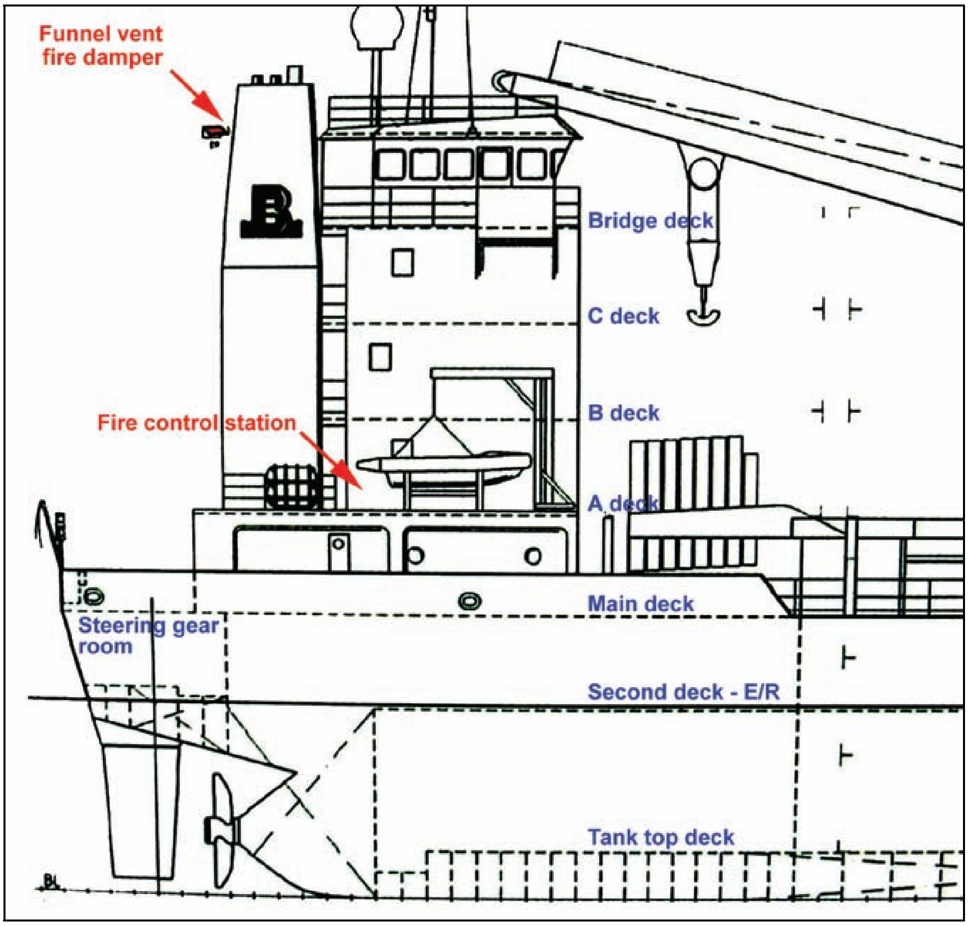
1.3 Fire control systems

Baltimar Boreas is fitted with fire protection, detection and extinction systems required for a ship of its size. For the machinery spaces, this includes a detection/alarm system and a fixed fire extinguishing system.

1.3.1 Fire detection and alarm system

Baltimar Boreas has a Salwico fire detection and alarm system to protect the ship's accommodation and machinery spaces (Figure 4). Heat or smoke activated fire detectors are fitted at various locations in the protected spaces. Break-glass push buttons to manually initiate the fire alarm are also provided on each deck.

Figure 4: Profile of accommodation and machinery spaces



The fire detectors are divided into eight independent loops or 'zones'. If a detector activates, a red light identifying the activated zone illuminates on a fire control panel located on the bridge (Figure 5). An audible alarm on the control panel also sounds and, after a short delay, the ship's fire alarm bells start ringing. Manual controls on the panel allow individual zones to be reset and bells to be turned off.

Figure 5: Fire alarm control panel

The UMS alarm panels in the engineers' cabins indicate a fire in the machinery spaces when a detector in any zone in these spaces is activated.

1.3.2 Fixed fire extinguishing system

Baltimar Boreas's engine room is protected by a Halon 1301 fixed fire extinguishing system engineered by Walter Kidde, Germany. Halon 1301, the common name for bromotrifluoromethane, is a colourless, odourless gas about five times denser than air. Halon 1301 also has low toxicity. The gas chemically reacts in a fire to inhibit the combustion process and has excellent fire extinguishing properties. Halon 1301 (Halon) is known as a clean agent because it leaves no residue.

Halon first came into use on board ships in the 1960s, but it has since been identified as an ozone depleting substance and is no longer used for new shipboard installations. Some Flag States, including the Bahamas, permit its use for existing installations as long as they remain serviceable.

Halon is stored on ships as a liquefied, compressed gas in cylinders in a similar manner to carbon dioxide. Halon offers the advantages of relatively low storage pressures and fairly small concentrations of gas give effective extinguishing capability, provided the required concentration of four and a quarter per cent of the gross volume of the protected space is reached quickly.

The extinguishing effectiveness of Halon, after discharge, is dependent upon the agent being present in at least the minimum concentration throughout the protected space for a period of time, commonly called the 'hold time'. Halon provides no cooling effect so there can be a danger of re-ignition if the space is ventilated too quickly after the gas has been discharged. Halon systems on ships are only required to have sufficient storage capacity for one complete discharge of the total gaseous charge provided.

Inside *Batimar Boreas*'s engine room, the Halon system comprises discharge nozzles and distribution piping supplied by four, separately located, and pneumatically operated Halon gas storage cylinders. The four cylinders, each designed to hold 69.1 kg of liquid Halon, are linked to ensure the simultaneous release of the total gaseous charge. On 5 September 2006, five months prior to the incident, a service agent had checked the cylinders in the engine room and found that they held the correct charge.

The ship's Halon system is operated remotely from the fire control station located on the port side of 'A' deck (Figure 4). The control station also contains the quick closing valve controls for engine room fuel, lubricating and other flammable oil tanks. Another panel inside the control station contains the emergency stops for various oil pumps, purifiers and ventilation fans.

Instructions for operating the ship's Halon system, copied from the system's operation manual, were posted inside the fire control station. The instructions were clear, concise and simple to follow, including an amendment requiring the engine room ventilation fans to be stopped manually.

1.4 The incident

At 2305 on 8 February 2007, *Baltimar Boreas* sailed from Kooragang berth number two, Newcastle, New South Wales. The ship was bound for Port Moresby, PNG, with a cargo of 80 containers and two truck bodies. Amongst the containers stowed on deck were 45 TEUs packed with a total of 945 tonnes of ammonium nitrate[6].

At 2345, after a normal passage out of Newcastle harbour, the pilot disembarked from *Baltimar Boreas*. Weather conditions were good with a cloudy sky, clear visibility and a south-westerly wind of about 15 knots. At 2355, the ship's course was set to 066º (T) and speed was increased to 12 knots for the sea passage.

The engineers completed their post departure checks before leaving the engine room unattended with the second engineer on call.

The master attended to paperwork and sent messages from the radio room on the bridge. Well after midnight, satisfied that the passage was proceeding normally, he told the second mate to observe his standing orders. The master then left the bridge.

At about 0100 on 9 February, the chief mate and crew completed securing the decks for sea and went to their cabins to rest.

At 0200, when the ship was off Port Stephens, its course was altered to 045º (T) (Figure 6). At about this time, the second engineer went to the engine room for a final inspection before going to bed. He found that everything appeared to be operating normally. At 0220, he left the engine room and returned to his cabin.

At 0250, the fire alarm panel on the bridge activated, indicating a fire in the engine room on the second deck. The second mate, as was usual practice on the ship, reset the alarm panel and waited to see if it would activate again. It did so immediately and he reset it again with the same result. Concerned, he tried to telephone the engineers in their cabins and then in the engine room. He got no response and decided to investigate the alarm himself.

At 0253, the second mate turned the fire alarm bells off and left the bridge. On his way downstairs, he smelled smoke and realised there was a fire. He hurried back to the bridge to find that other zones on the fire alarm control panel had also activated. He switched on the fire alarm bells and used the ship's public address system to alert the crew so that they could muster quickly.

The fire alarm had also activated in the engineers' cabin UMS alarm panels. The alarm woke the second engineer and he went to the engine room immediately. As soon as he entered the engine room, he saw flames on top of number three generator (Figure 7). He activated the manual fire alarm button adjacent to the engine room access door, picked up a portable fire extinguisher and approached the fire. He could not get closer than about 4 m from the fire, so he discharged the fire extinguisher towards the large red and yellow flames which appeared to him as though they were being fanned by the engine room ventilation fans. He then retreated from the fire, losing his spectacles as he hurried out of the engine room. After shutting the access door, he stopped the engine room ventilation fans from the panel near the stairs.

6 United Nations (UN) number 1942 dangerous goods classed as an oxidising substance by the International Maritime Dangerous Goods (IMDG) Code. The carriage of this industrial explosive involves a risk of explosion in certain circumstances.

Figure 6: Section of navigational chart Aus 362

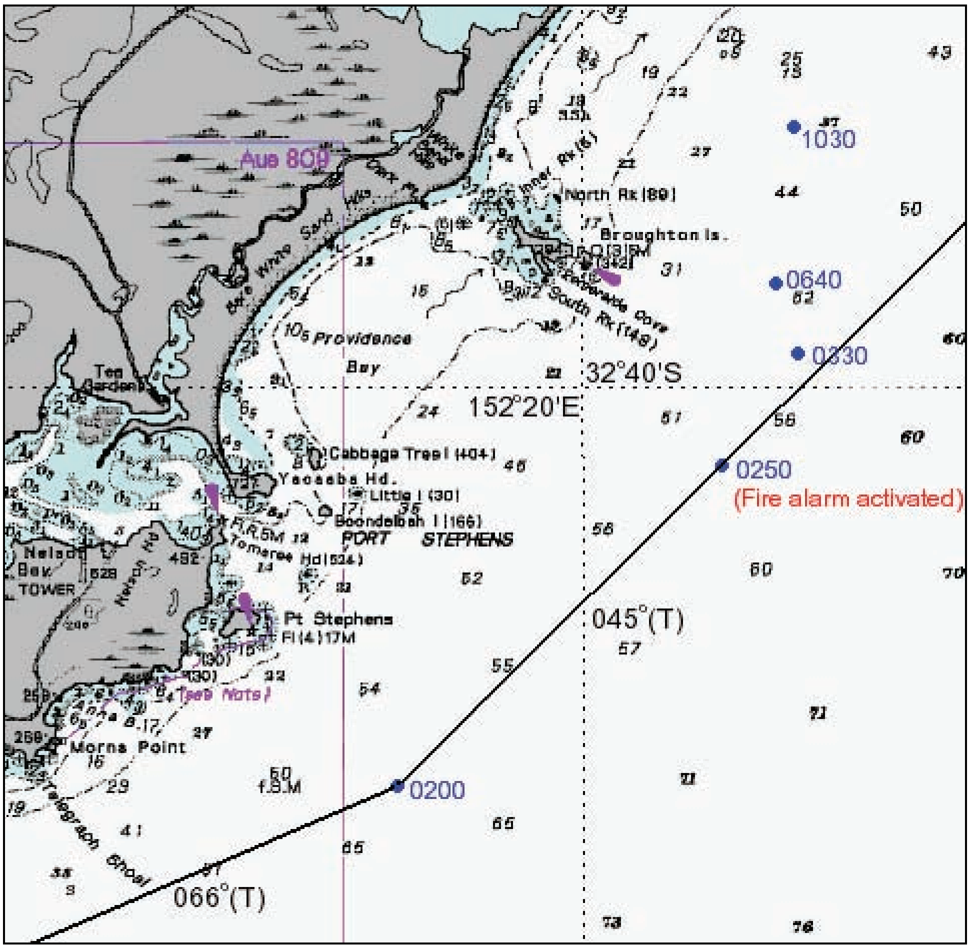
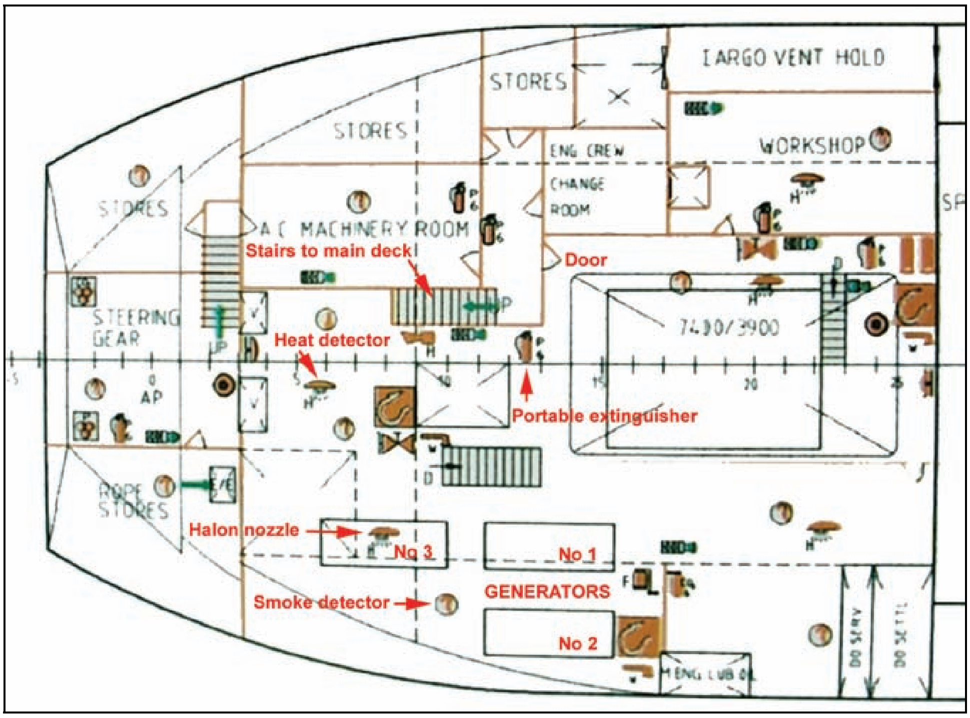


Figure 7: Elevation of engine room second deck



At 0255, the second engineer used the telephone in the engine crew change room nearby and reported the fire to the second mate on the bridge. He then ran up the stairs to the main deck shouting ‘Fire! Fire!’. He met the chief engineer making his way down and told him that number three generator was on fire. The second engineer then rushed up to the bridge.

The master, woken by the fire alarm bells, went to the bridge and saw thick black smoke coming from the funnel. The second engineer rushed in and told him about the large fire in the engine room. The smoke could be smelled on the bridge but the ship still had lighting and its main engine was still running.

The chief mate arrived at his muster point on the main deck with a hand held radio. Smoke was coming out of some ventilators and he began supervising the closing of all vents. He saw paint peeling off the hot deck on the starboard side of the accommodation and ordered the crew to shift the lubricating oil drums that were stowed close by. He also ordered the crew to rig fire hoses.

In the meantime, the chief engineer started the emergency generator before going to the fire control station and operating the engine room oil tank quick closing valve system and the emergency stops for pumps and fans. He was given a hand held radio by one of the crew.

At about 0258, the master went to the main deck and received verbal reports from the emergency teams. On his return to the bridge, the second mate told him that the amount of smoke from the funnel vents had increased. The master saw some sparks and flame coming out too. He thought about the explosive ammonium nitrate cargo on deck and quickly decided to use the engine room fixed fire extinguishing system (Halon system).

At 0300, the master ordered preparations to be made to operate the Halon system. The chief engineer asked the master about the open funnel vent fire dampers and was advised that it was not possible to close them at that time.

By 0305, all the crew had been accounted for and the master ordered the Halon to be released. The second engineer then operated the Halon system.

At 0308, the master made a distress call on the VHF radio stating that *Baltimar Boreas* was on fire in position 32º40.5’S 152º25’E. The ship was about five miles[7] off Port Stephens and the local volunteer coastal radio station acknowledged the ‘Mayday’ call and advised that a passing merchant ship, *Takayama*, would be requested to assist.

At 0312, the master sent a distress message via Inmarsat-C indicating that there was a fire in *Baltimar Boreas*’s engine room. The Australian Rescue Coordination Centre (RCC) received the message including the ship’s automatically transmitted position, 32º40’S 152º26’E, at the time. Through the ship’s AUSREP[8] reports, RCC also had other information about the ship, including its dangerous cargo.

Soon afterwards, the emergency generator stopped and the ship blacked out. At 0315, after clearing a blockage in the generator’s fuel line, the engineers restarted it. The emergency fire pump was then started from the bridge. The hottest areas were

7 A nautical mile of 1852 m.

8 The Australian Ship Reporting System operated by the Australian Maritime Safety Authority through RCC Australia in Canberra and designed to contribute to the safety of life at sea.

located on the starboard side of the accommodation, above number three generator. Floor tiles in the laundry had cracked and paint on the main deck outside it had peeled off. Fire hoses were used to spray water onto the hot surfaces on the boundary of the engine room. Two crew members donned self contained breathing apparatus (BA) in preparation for entering the engine room.

At about 0320, the chief mate led the two-man BA team to the engine room access door. He waited by the door while the two men, equipped with portable fire extinguishers, entered the engine room. They could see little through the thick smoke but discharged the extinguishers on some spot fires before exiting quickly.

By 0321, RCC had made a broadcast to shipping by relaying the distress message, including via Inmarsat-C, stating that *Baltimar Boreas*, with ten persons on board, had reported a fire. The distress relay provided the distress position, asking vessels within five hours of the position to report their 'best ETA[9]' and their intentions to RCC. Other vessels were requested to monitor communications.

At 0325, *Takayama* arrived to assist and stood by three miles away due to the nature of the cargo on board *Baltimar Boreas*. The volunteer coastal radio station at Port Stephens continued to monitor the situation via VHF radio communications.

On board *Baltimar Boreas*, boundary cooling continued and the amount of smoke coming from the funnel vents diminished. At 0330, the chief mate opened the engine room access door and reported that he could only see smoke and that the fire appeared to have been contained. He then led the BA team to the engine room and the two men re-entered the space and found no fire.

At 0340, the chief mate reported that the fire had been extinguished.

At about this time, the water police vessel, *WP24 Intrepid*, with volunteer marine rescue personnel from Newcastle on board, had been despatched by the local police to proceed to *Baltimar Boreas*'s position.

At 0344, RCC requested a tug from Newcastle with fire fighting capability to assist the ship.

At 0350, *Baltimar Boreas*'s emergency generator stopped again and, as a result, the fire pump stopped and boundary cooling ceased. The ship's emergency batteries provided power for the emergency lights and the communication equipment.

At 0351, the master reported to RCC that the fire was extinguished and cancelled his distress message. The volunteer coastal radio station at Port Stephens was also informed and it advised the master that *WP24 Intrepid* was about one and half hours away from arriving near the ship.

At 0410, the BA team entered the engine room again. They discharged a couple of portable fire extinguishers on suspected hot spots before leaving the smoke filled engine room. Ventilators were then opened to allow the smoke to disperse.

At 0505, the chief engineer and three crew members, not wearing BA, entered the engine room. Ten minutes later, the chief engineer reported that number three generator had been badly damaged by the fire and that the electrical cables above it were burnt and had 'collapsed' (Figure 8).

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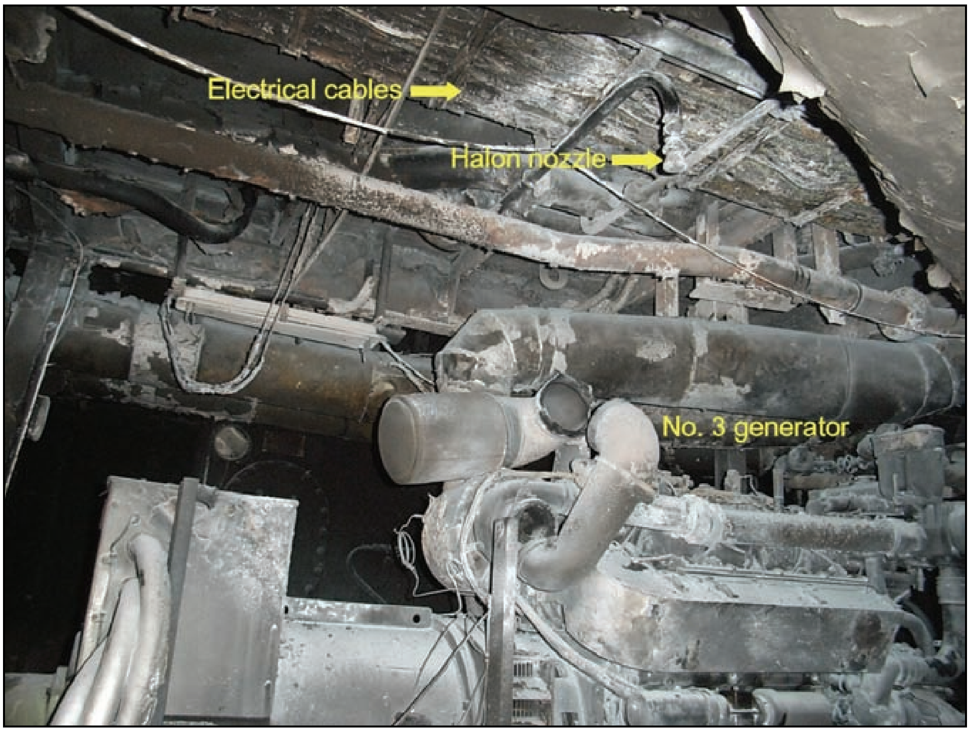
9 Refers to the earliest estimated time of arrival (ETA) at the distress position.

Figure 8: Number three generator and cables above it after the fire



The volunteer coastal radio station at Port Stephens and RCC continued to monitor the ship's situation. At 0512, RCC broadcast a message to cancel its earlier distress relay message and advised shipping that the fire on board *Baltimar Boreas* had been contained.

At 0518, *Baltimar Boreas*'s master confirmed to RCC that there were no injuries to the crew and that no fire fighting assistance was required. At 0526, RCC broadcast a message to shipping advising that *Baltimar Boreas* was adrift and requested that the disabled ship be given a wide berth.

At 0530, the master went to the engine room to discuss, with the chief engineer, restoring power and restarting the main engine.

At 0615, *WP24 Intrepid* arrived in the vicinity of *Baltimar Boreas* and confirmed the ship's status. Shortly afterwards, *Takayama* was allowed to resume its passage. *WP24 Intrepid* then stood by in case any assistance, such as a crew evacuation, was required before the tug *Wickham* from Newcastle, responding to the RCC request, arrived in the area.

By 0640, the chief engineer had started number two generator and determined that it was impossible to supply power to the main switchboard due to the seriously damaged electrical cables. The master reported the situation to the ship's managers via email.

Baltimar Boreas drifted slowly in a northerly direction (Figure 6) while the tug *Wickham* was en route to its position. The ship's managers had reached an agreement with the owners of the tug for the disabled ship to be towed back to Newcastle.

At 1023, *Baltimar Boreas* was five miles from Broughton Island when *Wickham* arrived. By 1030, a tow line had been connected for the 40 mile passage back to Newcastle and *WP24 Intrepid* was then stood down.

On arrival off Newcastle at 1635, a pilot boarded *Baltimar Boreas*. At 1920, with an additional tug assisting, the ship berthed at Kooragang berth number two. The port authority required the ammonium nitrate containers to be discharged and a tug to attend the disabled ship throughout the discharge of its dangerous cargo.

At 2110, cargo discharge was started with a shore crane. The ship's emergency generator had been restarted but it only provided power for some essential services.

At 1233 on 10 February, cargo discharge was completed. The ship was then shifted, under tow, to Dyke berth number one to undergo repairs.

1.4.1 The ship's return to service

Baltimar Boreas remained in Newcastle for the next four weeks. A reconditioned engine was supplied to replace the number three generator engine and repairs were made to the ship's electrical system. An electrical consultant from Germany supervised the repairs and remained on board the ship to assist.

Prior to the ship's departure from the repair berth, numbers one and two generators were surveyed by Lloyd's Register (LR). *Baltimar Boreas* was permitted to sail with only two operational generators. The following conditions of class, due to be cleared by April 2007, were imposed on the ship.

- The reconditioned generator was to be tested on completion of its installation.
- Engine room aft lighting was to be properly installed and secured.
- New flexible fuel hoses were to be fitted on numbers one and two generators.

At 0540 on 10 March, a pilot boarded and the ship, under its own power, was shifted to Kooragang berth number two to reload the ammonium nitrate containers.

At 1615, the ship sailed from Newcastle after reloading its cargo and resumed its voyage to Port Moresby.

On its next voyage to Australia about one month later, *Baltimar Boreas*'s first port of call was Brisbane, Queensland. On 9 April, while the ship was in Brisbane, it was surveyed by LR and all three conditions of class were cleared.

At 1645 on 9 April, *Baltimar Boreas* sailed from Brisbane with a pilot on board. At 1810, the ship blacked out and at 1814, despite letting go an anchor, it grounded in soft mud on the edge of the shipping channel.

At 1816, power was restored and the main engine was restarted. At 1904, *Baltimar Boreas* was refloated with two tugs in attendance and shifted to a safe anchorage.

At 0730 on 10 April, *Baltimar Boreas* was detained by the Australian Maritime Safety Authority (AMSA) pending confirmation of the ship's seaworthiness.

At 1030 on 11 April, the ship left the anchorage and was re-berthed in Brisbane at 1300. Subsequent investigation by AMSA and LR, with the electrical consultant assisting, identified a pinched control cable in number two generator governor motor circuit. A partial short circuit due to the pinched cable was considered to have been the most likely cause for the blackout.

Monitoring of the ship's tanks and compartments following the grounding indicated that the hull was not breached. A diver was not available in Brisbane for an underwater inspection of the hull.

On 13 April, AMSA and LR verified that faults in the ship's electrical system had been rectified. An internal hull inspection did not reveal any defects but LR imposed a condition of class on the ship pending an underwater inspection of its hull at the next port, Newcastle.

At 1030, AMSA released *Baltimar Boreas* from detention and the ship sailed from Brisbane that afternoon.

2 ANALYSIS

2.1 Evidence

On 10 and 11 February 2007, two investigators from the Australian Transport Safety Bureau (ATSB) attended *Baltimar Boreas* in Newcastle.

The ship's master, both mates and both engineers were interviewed and provided their accounts of the incident. Copies of log books, ship's certificates and other relevant documents, including those relating to the ship's safety management system and maintenance, were taken.

The investigators carried out an examination of the ship and a thorough investigation of the scene of the fire. Two fuel hoses on number three diesel generator were retained by the investigators for further technical analysis.

On 18 February, an investigator attended the ship while it was undergoing post fire repairs in Newcastle and collected additional documents relating to the generators.

During the investigation, relevant information was obtained from the Australian Maritime Safety Authority (AMSA), Lloyd's Register (LR) and Wartsila NSD Australia (Wartsila), the local representative of the manufacturer of the diesel generators.

2.2 The fire

The second engineer was at the scene of the fire soon after it started at about 0250 on 9 February 2007. He saw large red and yellow flames above number three generator which was the only generator running at the time.

The two fuel hoses retained by the ATSB investigators were located on top of number three generator and showed clearly visible signs of damage and failure. One of the failed hoses (Figure 3) was fitted between the feed pump and the duplex filter (filter hose) and the other hose led from the overflow valve to just above the deck where it was connected to the fixed return line (return hose). The return hose was found in two pieces. It had apparently separated when a temporary repair joining the two sections of hose had failed. Analysis of the filter hose confirmed that it had failed due to mechanical rubbing or chafing over a long period of time.

The failure of one of the two hoses identified would have provided the fuel for the fire. Leaking diesel oil from a failed hose would have sprayed over the top of the generator and some of it would have vaporised after making contact with hot surfaces on the generator engine. The mist of vaporised diesel would then have been ignited by a very hot surface at a temperature greater than the auto-ignition temperature of diesel oil[10].

Very hot surfaces[11] on the generator engine were shielded by lagging and metal sheathing and included the engine exhaust pipe, manifold and turbocharger.

10 The auto-ignition temperature of diesel oil, the lowest temperature at which it will ignite due to heat without the introduction of a flame, is 260ºC.

11 SOLAS regulations require surfaces with a temperature above 220ºC to be properly insulated.

However, a mist of vaporised diesel could have been ignited by a sufficiently hot surface near the extremities of the heat shielding. The most likely source of ignition was the turbocharger exhaust gas inlet which was operating at a temperature of approximately 300ºC.

The investigators found that the most serious fire damage was confined to number three generator and the electrical cables above it. Several components of the generator's control and fuel systems were also badly damaged, rendering it inoperable. The area adjacent to the generator had only minor smoke and radiant heat damage, mostly on the deck-head, the main deck above and inside the funnel casing which is immediately abaft the generator. Numbers one and two generators, about 1.5 m forward of number three generator, suffered only slight damage to some electrical components but were otherwise unaffected by the fire.

All the evidence indicated that both the source of fuel and ignition originated from number three diesel generator. Once ignited, fuel from the failed hoses fed the fire. The onsite investigation confirmed that a low spread, high intensity fire had started on the top of the generator and was extinguished before it caused any structural damage to the ship.

2.3 Fuel hoses

In 2000, DNV[12] determined that between 1992 and 1997, two-thirds of the 165 ship fires that it researched had started in the engine room. Of these, 56 per cent were caused by oil leakage onto a hot surface. The sources of oil leakage included damaged flexible hoses, couplings, filters and fractured pipes.

Flexible hoses are commonly the source of fuel in fires and SOLAS regulations and a number of International Association of Classification Societies (IACS) requirements aim to reduce the risk of a fire by limiting their use. Specific guidance is contained in an International Maritime Organization (IMO) circular[13] which states:

> Flexible pipes or hose assemblies, which are flexible hoses with end fittings attached, should be in as short lengths as practicable and only used where necessary to accommodate relative movement between fixed piping and machinery parts.

Lloyd's Register rules provide that any flexible hoses on fuel systems should be tested and approved by the society. The test requires that the hoses must withstand at least five times the working pressure in service. However, while the working pressure in the low pressure side of a diesel engine's fuel system may be relatively low, i.e. a few bar[14], the peak pressures which may be experienced in service can be much higher due to pressure pulses emanating from the cyclic operation of the fuel pump.

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12 Det Norske Veritas (DNV), Managing Risk, Engine room fires can be avoided, 2000.

13 IMO, Maritime Safety Committee (MSC)/Circular.647 – (adopted 6 June 1994) – Guidelines to Minimize Leakages from Flammable Liquid Systems.

14 1 bar = 100 kPa (approximately one atmosphere).

A relevant research[15] paper states:

> … pressure pulses of up to ten times the system working pressure of 8 bar exist over short periods of time (milliseconds). If cavitation occurs in the system due to its design, pressure pulses or “spikes”, in excess of 100 bar, can be experienced.

The research paper indicated that improved design of fuel systems by some engine manufacturers had attempted to reduce the problem of pressure pulses. However, it noted that many fuel systems with mis-matched pipework are in existence, the notation ‘low pressure’ having lulled shipyards, classification societies, repairers, owners and operators into a false sense of security.

The likelihood of the failure of flexible hoses due to pressure pulses and the risk of a fire is increased when the hoses are in poor condition. Their condition can deteriorate due to wear caused by incorrect fitting and maintenance. The following inspection and maintenance guidance suggested in IMO circular MSC 647 can, however, be used to effectively reduce the risk of a fire.

> Hose assemblies should be inspected frequently and maintained in good order or replaced when there is evidence of distress likely to lead to failure. Any of the following conditions may require replacement of the hose assembly:
>
> .1 leaks at fitting or in flexible hose;
>
> .2 damaged, cut, or abraded cover;
>
> .3 kinked, crushed, flattened, or twisted flexible hose;
>
> .4 hard, stiff, heat cracked, or charred flexible hose;
>
> .5 blistered, soft, degraded, or loose cover;
>
> .6 cracked, damaged, or badly corroded fittings;
>
> .7 fitting slippage on flexible hose.
>
> It is expected that hose assemblies may need to be replaced several times in the life of the ship. Manufacturer's recommendations should be followed in this respect. However, hoses should be replaced in good time whenever there is doubt as to their suitability to continue in service.

Further IMO guidance[16] on engine room oil fuel systems states:

> The ship Safety Management System should contain procedures to identify vibration, fatigue, defects, poor components and poor fitting of the fuel system and ensure that proper attention to protecting hot surfaces is maintained.

The rules and regulations of Lloyd’s Register, *Baltimar Boreas*’s classification society, are consistent with SOLAS and the IMO circulars. However, the evidence indicates that the use of flexible fuel hoses on *Baltimar Boreas*’s diesel generators and their maintenance was not consistent with these rules, regulations and guidelines.

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15 Marine Safety Agency, United Kingdom, Research work conducted by BMT Edon Liddiard Vince Limited, Failure of Low Pressure fuel systems on ship’s diesel engines, January 1997, MSA, UK.

16 IMO, Maritime Safety Committee (MSC)/Circular.851 – (adopted 1 June 1998) – Guidelines on Engine-Room Oil Fuel Systems.

2.3.1 *Baltimar Boreas*'s fuel hoses

Flexible hoses were used extensively in the fuel systems of *Baltimar Boreas*'s diesel generators. The use of rigid fuel pipes was mainly limited to the high pressure injection part of the system. Hoses constructed from a fuel resistant rubber hose enclosed in an outer layer of braided wire comprised most of the system's fuel lines. Banjo fittings and/or threaded connections crimped onto the ends of the hoses enabled them to be fitted to the various engine components.

Hoses of various lengths between 180 and 850 mm, according to the manufacturer's instruction book, were designed to be used in most positions. Some of the hoses actually fitted to the generators were more than 1 m long and extended from near the deck level, across the top of the engine and into its 'vee'. Hoses fitted in several positions were exposed to contact with hard surfaces at a number of locations. At many of these locations, expanded rubber foam or plastic sleeves had been used in an attempt to protect the hoses from chafing.

The designed length and arrangement of the generator fuel hoses were not consistent with the IMO guidance. They were neither as short as practicable nor used only where necessary to allow for relative movement between the fixed piping and engine components. Furthermore, it was evident that, at some time in the past, the crew had fitted even longer hoses than those specified by the generator manufacturer.

The failed hoses

The ATSB examination of the two failed hoses (the filter hose and the return hose) showed that they comprised a single protective outer layer of braided wire enclosing an internal fuel resistant rubber hose. The filter hose was connected to the feed pump inside the 'vee' of number three generator engine and its 700 mm length was led across the charge air cooler before being connected to the duplex fuel filter (Figure 9).

Figure 9: Failed 'filter hose' in situ with two visible areas of damage

No markings were found on the filter hose to indicate its part number or manufacturer. However, the hose's length and end fittings suggest that it was consistent with the manufacturer's specifications for the hose to be fitted in that position. Four distinct, significantly sized areas of damage were identified on the hose. Examination of the damaged areas under a low power stereo microscope indicated that abrasive wear was the principal process of primary wire braid failure in each location (Figure 10). Further examination under a scanning electron microscope confirmed that each wire in the braid had been worn to a thin flat profile by a process of wear. No other failure mechanisms, such as overload from excessive pressure or wire fatigue from cyclic oscillations, were evident.

Figure 10: Close-up of the filter hose's wire braid wear

Analysis of the filter hose indicated that wear of the wire braid took place over a considerable period of time while it was in hard contact with solid surfaces on the engine. Vibration of the engine and fuel pressurisation cycles would have provided the necessary conditions for the process. Burnt rubber foam covered an area of pre-existing wire braid damage and indicated that an attempt to isolate the hose from further damage had been made some time before the fire.

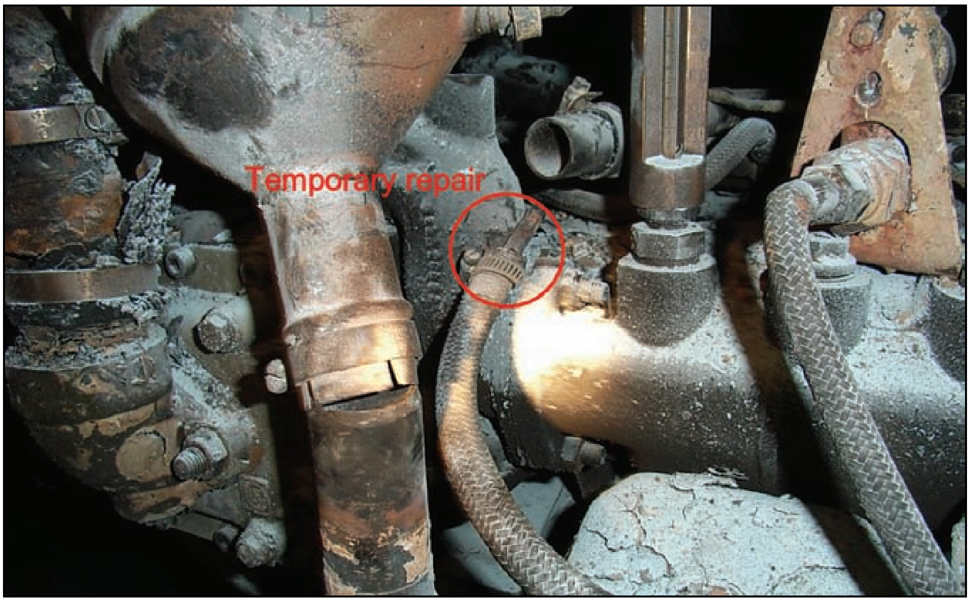
The filter hose could have failed at any of the four areas of damage located on it. As the fire had affected the entire length of the internal rubber hose, it was impossible to say with certainty exactly where the hose may have failed before the fire. However, it is likely that the hose's failure provided the fuel to initiate the fire. It operated at a higher pressure than the return hose even though both may have been subject to much higher than normal pressures for very short periods of time due to pressure pulses in the generator's low pressure fuel system. The filter hose's normal working pressure was probably between two and five bar.

In two areas of damage on the filter hose, including the one shown in Figure 10, the internal rubber hose had been entirely consumed. This indicates that the intensity of the fire was much greater in these locations. Once the wire braid at either location was worn, wear on the internal rubber hose would have weakened it. The evidence therefore indicates that a failure at either of these locations was more likely to have provided fuel to start the fire.

The return hose probably failed after the fire started. The hose extended from the stop solenoid and overflow valve on top of the engine, across the exhaust manifold casing and down to deck level. A temporary repair had been made to it by inserting a copper pipe between two pieces of the hose with a jubilee clip on either side to hold the connecting pipe in place. The repair is likely to have been made because of the lack of spares and on the basis that it was thought to be acceptable because the pressure in the hose was relatively low.

The wire braid on both sides of the temporary repair was worn where the hose had initially failed before being repaired. The hose then failed when the repair had come apart, probably after the fire started. The copper pipe remained attached to the longer lower part of the hose (Figure 11).

Figure 11: Failed 'return hose', lower part, in situ



The ATSB's analysis revealed that the assembly and layout of the generator's fuel hoses meant that there were points of hard contact with other engine components which contributed to the wear and eventual failure of the filter hose. The failure of this hose then probably provided the fuel which led to the fire.

A similar hose failure in 2003

On 2 December 2003, part of a message from *Baltimar Boreas*'s master to the ship's managers requesting spares after a hose failure read:

> 2 pc only. Fuel line as per sample (Braided Flex Hose. Banjo/Female Fittings)
>
> FYI No. 1 Gen. Hose ruptured 23:55 last night. Pump to filter position. Fuel everywhere. No alarm, heavy fuel smell in accom vent system was only indication. Should have changed full hose run as the after section failed last trip. hve taken spare from No. 2. (which is waiting for new JW manifold). A bilge alarm would hve ultimately sounded but by then we could have had a nasty fire.

In this case, a generator engine filter hose had failed but the leaking fuel did not ignite. The incident did, however, highlight the risks due to the fuel system hoses and the possibility of a 'nasty fire' was recognised and made known to the ship's managers.

At the time, the chief engineer had also acknowledged that the full hose run should have been changed after a previous hose failure. He ordered two hoses, one to replace the failed hose and another as a spare. This indicates that hoses were replaced when considered necessary due to failure or poor condition but spares were not always kept on board. There was no evidence to indicate that a hose register or similar record, with hose ordering and replacement, or a spares inventory with current stock records had ever been maintained on board the ship.

Condition and maintenance of hoses

The history of the two failed hoses was not recorded and could not be traced. Consequently, the age of the hoses and any maintenance carried out on them, including the temporary repair to the return hose, could not be determined.

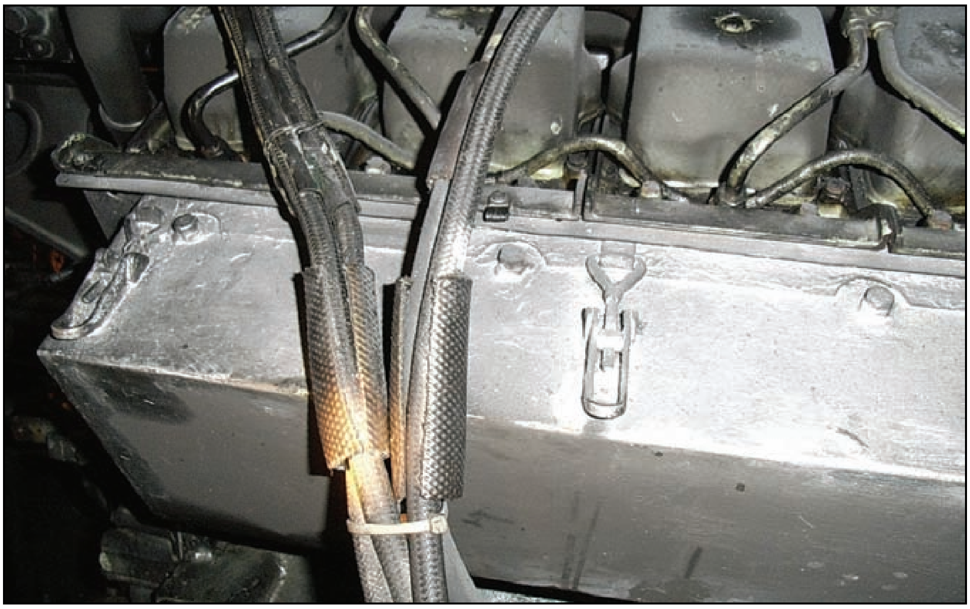
The ship's safety management system (SMS) did not specify any periodic maintenance or replacement intervals for the generator fuel hoses. Generator maintenance was based mainly on the manufacturer's instruction book which provided a fault tracing table, servicing schedule and overhaul periods but no guidance for maintenance or replacement of the fuel hoses. In this regard, the manufacturer advised the ATSB that:

> At daily routine checks from the engine by the engineers they have to notice and interact when flexible lines aren't flexible any more! [sic]

The ship's SMS contained an engine room checklist which included the daily checking of 'auxiliary engine cooling water, lube oil and fuel leakage'. During the fortnight before the incident, the check had been recorded as 'OK' indicating that no fuel leakage or potential leakage had been detected by the engineers during their daily inspections.

The extensive use of protective rubber or plastic sleeves, held in place with seizing wire or cable ties, on the fuel hoses suggests that the engineers had recognised the risks of the hoses chafing and had taken measures to prevent wear (Figure 12). In some locations, the sleeves had vibrated, slipped or come loose, leaving the hose unprotected. A few locations where the hoses were in contact with hard surfaces and could suffer wear damage had also been overlooked. Temporary repairs, similar to that found on the failed return hose, had also been made to other hoses.

Figure 12: Protective sleeves on hoses



In the absence of adequate SMS procedures on board or guidance in the manufacturer's instruction book, fuel hose maintenance and replacement relied on hose failure, not planning. Furthermore, hoses longer than specified by the generator manufacturer were being used. As recently as 14 May 2006, an order had been placed for spare hoses quoting the manufacturer's part numbers but requesting significantly longer lengths than those specified by the manufacturer. For example, one of the hoses ordered was 1500 mm instead of the 580 mm length specified by its part number.

The ship's SMS required only the chief engineer to provide written handover notes. The handover notes of the previous two chief engineers did not indicate any problems with the fuel hoses nor did their standing orders refer to the hoses. The second engineer did not have any handover notes and, consequently, there was no written or formal exchange of information or guidance about fuel hoses between successive second engineers. The engine room work book included scheduled generator servicing but no fuel hose maintenance during the six months before the incident had been recorded.

With no fuel hose records and no specified intervals for their replacement, it was not possible to determine the age of the hoses. However, based on the generator engine running hour records, the engines were probably replaced about eight years before the fire. Assuming that new hoses were fitted at the time, any hoses not since replaced may have been in use for eight years. The age of the hoses, given their arduous conditions in service with no fixed replacement intervals, increased the likelihood of their failure and the risk of a fire.

Baltimar Boreas's managers also managed seven of its sister ships with the same type of diesel generators. Therefore, it is likely that incidents such as the hose failure in 2003 and other hose maintenance issues on these eight ships had come to the attention of the managers. However, there was no evidence in the form of guidance and procedures within the ship's SMS, to indicate that the risk of a hose failure had been adequately addressed.

Similarly, Lloyd's Register (LR) had not identified any irregularities with the generator fuel hoses during class approval and continuous machinery surveys. Since it was built, *Baltimar Boreas* had been classed by LR for all but two of the ship's 18 years in service. The IMO circulars providing relevant guidance for fuel systems were adopted in 1994 and 1998, before the ship's generator engines were replaced. Furthermore, on behalf of the Flag State, LR was also responsible for conducting audits and issuing certification required under the ISM (International Safety Management) Code for the ship and its managers.

In their submission, with regard to the length, arrangement and condition of the generator fuel hoses, Lloyds Register stated:

> This is a maintenance issue and should be covered by the ships' staff as per Engine Manufacturer's instructions. Lloyd's Register should not be held responsible for this action.
>
> However, during course of our Survey or ISM audit, provided these defects were reported or observed, LR would not agree to temporary repairs of flexible hoses being carried out by means of inserting copper tubing and jubilee clips. Our surveyors would always require that such repairs or renewals are carried out in accordance with the engine manufacturer's instructions.

In this case the engine manufacturer provided no guidance on the maintenance and replacement of the flexible fuel hoses. While the crew has an important role in managing the safety of the ship, it must be supported by the ship's managers, the classification society and the Flag State. The evidence indicates that *Baltimar Boreas*'s generator fuel hoses were not in compliance with applicable regulations and guidelines to reduce the fire risk. Even after the fire, the grounding and the repairs and surveys after each incident, no irregularities appear to have been noted by LR or the ship's managers. In such a situation, particularly over long periods of time, it is likely that if readily apparent hazards are overlooked, higher risks become acceptable and poor practices become the norm for the ship's crew.

Evidence of wear, similar to that found on the failed fuel hoses, was evident on other generator fuel hoses. The condition of the failed hoses, their unnecessary length, poor arrangement and the condition of other fuel hoses together with a lack of documentary evidence, indicated that there was no planned maintenance or other systematic regime on board *Baltimar Boreas* to effectively maintain these hoses.

2.4 Shipboard emergency response

The fire was extinguished because it was detected quickly and the initial response of the crew was rapid and effective. Fortunately, circumstances that could have adversely affected the outcome did not eventuate.

It is likely that the smoke detector about one metre away from number three generator activated first, setting off the fire alarm at 0250 on 9 February. Less than two minutes later, the second engineer was at the scene of the fire. Soon after, when he realised that the fire was too large to fight locally, he stopped the engine room ventilation fans. Leaking fuel did not accumulate because the fire probably started shortly after the hose failure. About seven minutes after the fire started, the chief engineer operated the engine room oil tank quick closing valve system. With no fuel and the fans stopped, the fire was being starved.

At 0305, about fifteen minutes after the fire started, the Halon system was operated and the gas probably extinguished the already starved fire very quickly. The Halon nozzle located above number three generator (Figure 8) ensured that some of the gas was released immediately above the seat of the fire and would have quickly started to inhibit the combustion process. The fire dampers for the funnel vents could not be closed. Some Halon would have risen with the smoke and escaped from the open vents, particularly as the funnel casing lay immediately abaft the seat of the fire.

Once cooling of the engine room boundary was started, preparations for entry into the space were made. The Halon system's instruction book on board the ship contained the following caution:

> For deep seated fire hazards, the hazard space should be kept tightly closed for 30 to 60 minutes after discharge of the Halon 1301 agent. Be sure fire is completely extinguished before ventilating area. Before permitting anyone to enter the space, ventilate area thoroughly or ensure self-contained breathing apparatus is being used.

At about 0320, just 15 minutes after the release of the Halon, the engine room entry was premature. The presence of spot fires on entry suggests that the hold time was insufficient. Not allowing sufficient hold time for the engine room to cool increased the likelihood of the fire reigniting. Entering the engine room also made it more likely that some Halon would escape through the funnel vents due to the natural draught of the air flow from the access door at the second deck level, thereby diluting the concentration of Halon in the engine room.

No personnel rescue was required and the disabled ship was not in any immediate danger of drifting closer to the coast. The ship was carrying an explosive cargo and the consequences of the fire reigniting, particularly as the single use Halon system had already been operated, could have been severe. Essentially, entering the engine room so early increased the risk to the ship when there was nothing to be gained from this action.

The ship's SMS provided a flow chart for the actions to take in the event of an engine room fire. The penultimate step in the chart stated that 'Halon should only be released after the master's orders'. The chart contained no reference to the Halon system's instruction book nor did it provide any other guidance with regard to entering the engine room after the release of Halon. It is evident that the master and crew were not aware of the caution contained in the Halon system's instruction book and in their keenness to investigate, entered the engine room unnecessarily early which resulted in added risks for the entry team and the ship.

The master sent a distress message as soon as possible after operating the Halon system. However, at 0351, he cancelled the distress even though there were problems with the emergency generator and a thorough investigation of the engine room had not been completed. It is possible that he felt confident because a ship was standing by to assist even though he had not taken the precaution of preparing to abandon ship.

The timely and correct initial response of the crew, despite the premature engine room entry and the open funnel vents, was sufficient to limit the consequences of the fire.

2.5 Funnel vent fire dampers

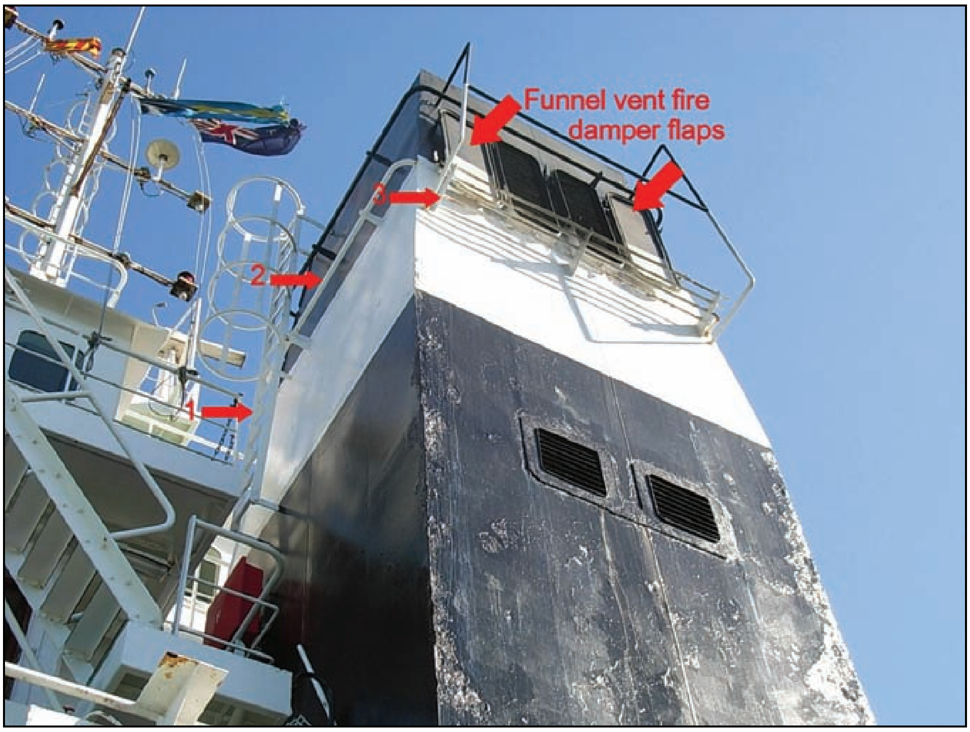
The SOLAS requirements applicable to *Baltimar Boreas* at the time that the ship was built state:

> … means of control shall be provided for … closure of openings in funnels which normally allow exhaust ventilation … and that these controls shall be located outside the space concerned, where they will not be cut off in the event of fire in the space they serve.

The intent of the requirements is to ensure that controls to close funnel vents will not be cut off in the event of an engine room fire and, therefore, the controls should remain accessible.

Baltimar Boreas's funnel vent fire dampers (Figure 13) could not be closed remotely, with provision only for physically closing them locally. Access was via a ladder (1) on the port side of the funnel, then by holding a rail while standing on another rail (2) and moving to the platform (3) on the aft part of the funnel. Here, while standing on the platform about 12 m above the main deck, the two damper flaps could be closed and dogged shut. Furthermore, closing the flaps required moving across an open vent at least once. With the emission of smoke, sparks and flame from the vents during the fire, closing the damper flaps was practically impossible.

Figure 13: Access to funnel vent fire damper flaps



The ship's funnel vent closing arrangements, therefore, did not meet the intent of the relevant SOLAS requirements and similar Lloyd's Register (LR) fire safety measures and rules. Despite this, they had been approved by LR and passed during subsequent class surveys. There was also no evidence to indicate that the deficiency had been noted by LR during audits required under the ISM Code or noted during maintenance, drills and inspections and reported.

In submission Lloyds Register stated:

> From LR's point of view, we are of the opinion that the closing arrangements of openings in the funnel meets the above SOLAS requirements as they are located out side machinery spaces & will not be cut off in event of fire in machinery spaces.
>
> It is noted that the crew faced difficulties in closure due to emission of smoke & sparks. This should be covered by additional fire drills and shipboard instructions should highlight the importance of closing these openings before the fire reaches such an extent that the crew are unable to gain access to the external controls.

While the fire dampers are located outside the machinery spaces, access to them was certainly cut off in the fire. The 'external controls' referred to by LR are the damper flaps which can only be manually closed. They will inevitably become inaccessible when smoke, and heat, is issuing from the vents. Furthermore, it is evident from this incident that the dampers could quickly be cut off and a rapid response from the crew, as in this case, will not be sufficient. The dark early hours of the morning with little, if any lighting, further complicated any response.

Closing *Baltimar Boreas*'s dampers, if attempted in a fire, unlike remotely operated external controls (usually wire/s and/or counter-weight/s) commonly found on funnel fire dampers, involved sending crew aloft while wearing cumbersome fire protection equipment. Going up the ladder (with its safety hoops), then moving along the rails, using a harness/lifeline, to the vents from which smoke and heat are issuing and then closing the dampers would represent an unacceptable risk for the crew involved. The closing arrangements must be capable of being operated as intended by the relevant SOLAS regulation.

Furthermore, the risks of such funnel vent closing arrangements have also been highlighted in a similar previous incident. On 24 May 2005, an engine room fire occurred on a nearly identical ship, *Java Sea*, whilst it was berthed in Cairns, Queensland. The ATSB investigation (report number 215) concluded that one of the reasons for the fire not being extinguished was the open funnel vents through which the Halon escaped after being released. The report also concluded that without the prompt and effective assistance of the Queensland Fire Service it was likely that the damage to the ship and risk to the crew would have been much worse.

The funnel vent closing arrangements of *Java Sea*, like those of *Baltimar Boreas*, had been approved by LR. In October 2006, about four months before the fire on board *Baltimar Boreas*, a draft copy of ATSB report number 215, which included the findings described above, was provided to LR. The funnel vent closing arrangements of *Baltimar Boreas* and similar sister ships exposes them to very high risks in the event of an engine room fire.

2.6 Single person bridge watches

At the time of the first fire alarm, *Baltimar Boreas*'s second mate was alone on watch. He left the bridge unattended to investigate the alarm because he could not contact the engineers. The STCW Code[17] has a number of requirements for navigational (bridge) watch-keeping with regard to the keeping of a proper lookout at all times in accordance with the COLREGS[18].

A primary responsibility of the bridge watch is to keep a proper lookout. If the officer of the watch is the sole lookout and is incapacitated or distracted when performing other necessary tasks, there is effectively no lookout. Keeping a lookout is more difficult during the hours of darkness which are also outside the usual daytime crew working hours, making it likely that the incapacitation of a single bridge watch-keeper may not be noticed for a considerable period of time.

The STCW Code advises that the officer of the watch may be the sole lookout in daylight provided that the weather, visibility, traffic density and proximity to dangers, amongst other factors, have been taken into account to effectively manage the navigational risks. With regard to the hours of darkness, the Code states:

> The master and officer in charge of the navigational watch, when arranging look-out duty, shall have due regard to the bridge equipment and navigational aids available for use, their limitations; procedures and safeguards implemented.

The Code also states that at no time shall the bridge be left unattended and it makes a number of references to the impairment of night vision and other duties that may be an impediment to the keeping of a proper lookout. The standing orders of *Baltimar Boreas*'s master also required that the mates maintain a proper 'visual' lookout at all times.

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17 IMO, Seafarer's Training, Certification and Watchkeeping Code, Chapter VIII, Part 3, Watchkeeping at Sea.

18 The International Regulations for Preventing Collisions at Sea, 1972, as amended.

Navigational risks are higher in coastal waters where traffic density is generally greater than in the open sea far away from land and a dedicated lookout may be necessary at all times, particularly during the hours of darkness. The dedicated lookout should perform only lookout duties, and not for example steering duties, to ensure that the officer of the watch is adequately supported.

Some ships are fitted with a bridge dead-man alarm system as a safeguard to reduce the risk due to the incapacitation of the officer of the watch, particularly when the officer may be the sole lookout. *Baltimar Boreas* was not fitted with a dead-man alarm system.

Ships with small crew numbers, such as *Baltimar Boreas*, find it more difficult to have a dedicated lookout at night particularly after the usually longer working hours in port and thus the increased exposure of the crew to fatigue. These issues should be carefully considered and addressed when a ship's manning level is decided.

At the time of the fire, a dedicated lookout was not posted on *Baltimar Boreas*'s bridge. The high risks that the ship was exposed to in the prevailing conditions were further increased when the second mate left the bridge unattended to investigate the fire alarm.

2.7 Response from ashore

The fire on board *Baltimar Boreas* was a serious incident which could have had severe consequences, particularly as the ship was carrying a potentially explosive cargo. The ship was just five miles from the coast increasing the likelihood of a grounding and pollution on or near the coast. An appropriate response by authorities ashore was necessary to reduce the risks to the ship, its crew and the environment.

The incident occurred outside state waters and the Australian Maritime Safety Authority (AMSA) was responsible for managing the response. Within AMSA, the response was coordinated by RCC which responds to such incidents inside the Australian search and rescue area. Receipt of a distress message by RCC, in addition to relaying the message, results in immediate internal notifications to the maritime operations and environmental protection business units of AMSA so that appropriate action can be taken.

At 0321 on 9 February, less than 10 minutes after receiving *Baltimar Boreas*'s distress message reporting an engine room fire, RCC broadcast a distress relay so that assistance from vessels in the area could be coordinated. Other information about the ship was available from its AUSREP reports. The Port Stephens volunteer coastal radio station assisted through VHF radio communications with the ship.

By 0325, a passing ship, *Takayama*, was standing by three miles away from *Baltimar Boreas*. This was considered a safe distance by RCC due to *Baltimar Boreas*'s dangerous cargo. Within half an hour of the ship's distress message, a water police vessel, with marine rescue volunteers on board, was en route to *Baltimar Boreas*'s position. In addition, RCC also requested a tug from Newcastle with fire fighting capability to assist.

At 0351, the master reported to RCC that the fire was extinguished and asked for his distress message to be cancelled. Prudently, RCC continued to monitor the situation and cancelled its distress relay only at 0512 after receiving further confirmation that the fire had been contained. *Takayama* was kept standing by until after 0615, when the police vessel, *WP24 Intrepid*, arrived.

WP24 Intrepid then stood by *Baltimar Boreas* and the volunteer coastal radio station maintained communications with the ship until the tug *Wickham* arrived. The disabled ship did not drift significantly closer to the coast and by 1030 was under tow to Newcastle. After *Baltimar Boreas* berthed, a tug attended until the ship's dangerous cargo had been discharged. The ship was then safely towed to its repair berth.

The initial response by AMSA to *Batimar Boreas*'s distress message and the subsequent actions ashore to coordinate and manage the incident were timely, well managed and appropriate.

3 FINDINGS

3.1 Context

At 0250 on 9 February 2007, about four hours after *Baltimar Boreas* sailed from Newcastle; the ship's fire detection system indicated a fire the engine room. The second engineer found number three diesel generator on fire, discharged a portable fire extinguisher towards it, then retreated and stopped the engine room ventilation fans. The crew mustered and operated the engine room oil tank quick closing valve system. All ventilators, except those at the top of the funnel, were closed.

At 0305, the Halon fixed fire extinguishing system for the engine room was operated and soon after, a distress message was sent. At 0340, the fire was reported extinguished. The ship's electrical system was badly damaged and *Baltimar Boreas* was disabled. Later that day, a tug responding to the ship's distress call towed it back to Newcastle for repairs.

From the evidence available, the following findings are made with respect to the engine room fire and should not be read as apportioning blame or liability to any particular organisation or individual.

3.2 Contributing safety factors

- Long term damage due to rubbing and chafing contributed to the failure of a flexible fuel hose on *Baltimar Boreas*'s number three diesel generator and provided the initial source of fuel for the fire.
- Diesel oil from the failed flexible fuel hose vaporised and then ignited on a very hot surface on number three generator, probably near the end of the heat shielding of the turbocharger exhaust gas inlet.
- The maintenance of the generator flexible fuel hoses was inadequate. Inappropriate temporary repairs had been made and hoses longer than specified by the generator manufacturer had been used in the past. As a result, some hoses were in poor condition due to wear and this had not been noted during previous surveys, audits and inspections. *[Safety issue]*
- The generator manufacturer's instruction book provided no guidance for the maintenance or routine replacement of the flexible fuel hoses. *[Safety issue]*
- *Baltimar Boreas*'s safety management system provided no guidance for the maintenance or replacement of the generator flexible fuel hoses. *[Safety issue]*
- The design of *Baltimar Boreas*'s diesel generator fuel system with respect to the length and arrangement of its flexible fuel hoses was not in accordance with International Maritime Organization guidelines. A number of the hoses were not as short as practicable and their use was not limited to only those positions or locations where it was necessary to accommodate relative movement between engine components. *[Safety issue]*

3.3 Other safety factors

- While *Baltimar Boreas*'s Halon fixed fire extinguishing system's instruction book provided guidance with regard to the minimum time to allow before considering entry into the protected space after the release of Halon, the master and crew were not aware of the guidance and entered the engine room too soon after the Halon was released. *[Safety issue]*
- The emission of smoke, sparks and flame from *Baltimar Boreas*'s funnel ventilators just after the engine room fire started effectively cut off access to their locally operated fire dampers which prevented them from being closed. The closing arrangements for the ship's funnel ventilators, therefore, did not comply with the intent of the relevant provisions of the International Convention for the Safety of Life at Sea (SOLAS). *[Safety issue]*
- At the time of the fire, *Baltimar Boreas* did not have a dedicated lookout on the bridge during the hours of darkness. The high navigational risks that the ship was exposed to at night while navigating coastal waters were further increased when the second mate left the bridge unattended to investigate the fire alarm. This was inconsistent with sound bridge watch-keeping practice prescribed in the Seafarer's Training, Certification and Watchkeeping (STCW) Code and it was also in contravention of the international regulations for preventing collisions at sea. *[Safety issue]*

3.4 Other key findings

- The timely and correct initial response of *Baltimar Boreas*'s master and crew, and the actions of the second engineer in particular, resulted in the fire being successfully extinguished.
- The Australian Maritime Safety Authority's response to, and management of, the incident from ashore was timely, well managed and appropriate.

4 SAFETY ACTIONS

4.1 ATSB recommendations

MR20080020

The maintenance of the generator flexible fuel hoses was inadequate. Inappropriate temporary repairs had been made and hoses longer than specified by the generator manufacturer had been used in the past. As a result, some hoses were in poor condition due to wear and this had not been noted during previous surveys, audits and inspections.

The Australian Transport Safety Bureau recommends that Baltimar A/S take action to address this safety issue.

MR20080021

The generator manufacturer's instruction book provided no guidance for the maintenance or routine replacement of the flexible fuel hoses.

The Australian Transport Safety Bureau recommends that Wartsila NSD Australia take action to address this safety issue.

MR20080022

Baltimar Boreas's safety management system provided no guidance for the maintenance or replacement of the generator flexible fuel hoses.

The Australian Transport Safety Bureau recommends that Baltimar A/S take action to address this safety issue.

MR20080023

The design of *Baltimar Boreas*'s diesel generator fuel system with respect to the length and arrangement of its flexible fuel hoses was not in accordance with International Maritime Organization guidelines. A number of the hoses were not as short as practicable and their use was not limited to only those positions or locations where it was necessary to accommodate relative movement between engine components.

The Australian Transport Safety Bureau recommends that Lloyd's Register take action to address this safety issue.

MR20080024

The design of *Baltimar Boreas*'s diesel generator fuel system with respect to the length and arrangement of its flexible fuel hoses was not in accordance with International Maritime Organization guidelines. A number of the hoses were not as short as practicable and their use was not limited to only those positions or locations where it was necessary to accommodate relative movement between engine components.

The Australian Transport Safety Bureau recommends that Wartsila NSD Australia take action to address this safety issue.

MR20080025

The emission of smoke, sparks and flame from *Baltimar Boreas*'s funnel ventilators just after the engine room fire started effectively cut off access to their locally operated fire dampers which prevented them from being closed. The closing arrangements for the ship's funnel ventilators, therefore, did not comply with the intent of the relevant provisions of the International Convention for the Safety of Life at Sea (SOLAS).

The Australian Transport Safety Bureau recommends that Lloyd's Register take action to address this safety issue.

4.2 ATSB safety advisory notices

MS20080021

The maintenance of the generator flexible fuel hoses was inadequate. Inappropriate temporary repairs had been made and hoses longer than specified by the generator manufacturer had been used in the past. As a result, some hoses were in poor condition due to wear and this had not been noted during previous surveys, audits and inspections.

The Australian Transport Safety Bureau advises that ship owners, operators and managers should consider the safety implications of this safety issue and take action when considered appropriate.

MS20080022

The generator manufacturer's instruction book provided no guidance for the maintenance or routine replacement of the flexible fuel hoses.

The Australian Transport Safety Bureau advises that the manufacturers of marine diesel engines should consider the safety implications of this safety issue and take action when considered appropriate.

MS20080023

Baltimar Boreas's safety management system provided no guidance for the maintenance or replacement of the generator flexible fuel hoses.

The Australian Transport Safety Bureau advises that ship owners, operators and managers should consider the safety implications of this safety issue and take action when considered appropriate.

MS20080024

While *Baltimar Boreas*'s Halon fixed fire extinguishing system's instruction book provided guidance with regard to the minimum time to allow before considering entry into the protected space after the release of Halon, the master and crew were not aware of the guidance and entered the engine room too soon after the Halon was released.

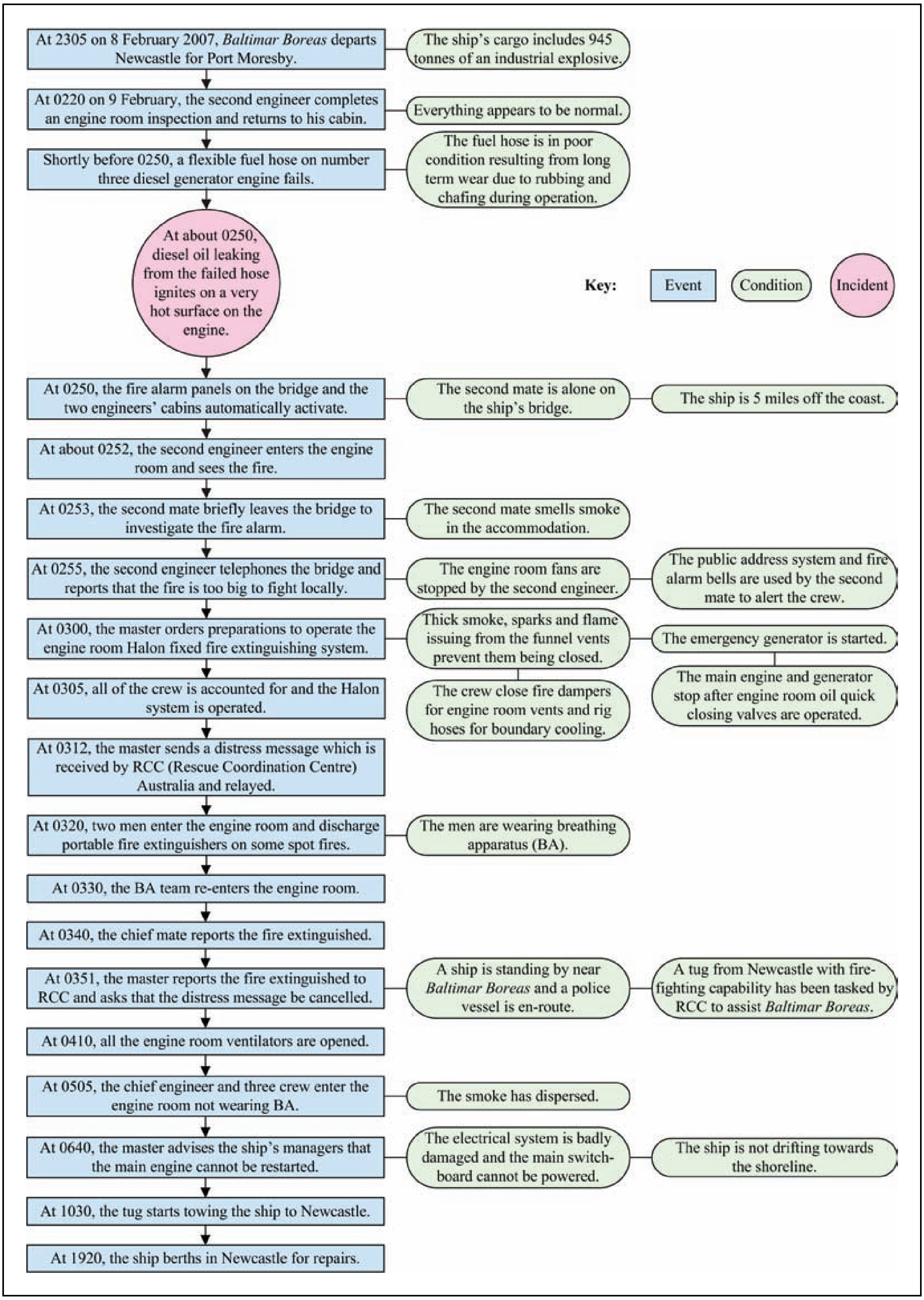
The Australian Transport Safety Bureau advises that ship owners, operators and masters should consider the safety implications of this safety issue and take action when considered appropriate.

MS20080025

At the time of the fire, *Baltimar Boreas* did not have a dedicated lookout on the bridge during the hours of darkness. The high navigational risks that the ship was exposed to at night while navigating coastal waters were further increased when the second mate left the bridge unattended to investigate the fire alarm. This was inconsistent with sound bridge watch-keeping practice prescribed in the Seafarer's Training, Certification and Watchkeeping (STCW) Code and it was also in contravention of the international regulations for preventing collisions at sea.

The Australian Transport Safety Bureau advises that ship owners, operators and masters should consider the safety implications of this safety issue and take action when considered appropriate.

APPENDIX A: EVENTS AND CONDITIONS CHART



APPENDIX B: SHIP INFORMATION

Baltimar Boreas

IMO Number	8807349
Call sign	C6HY7
Flag	Bahamas
Port of Registry	Nassau
Classification society	Lloyd's Register (LR)
Ship Type	General cargo ship
Builder	Zhonghua Shipyard, China
Year built	1989
Owners	Superseven Shipping, Bahamas
Ship managers	Baltimar A/S, Denmark
Gross tonnage	2854
Net tonnage	941
Deadweight (summer)	3188 tonnes
Summer draught	4.99 m
Length overall	91.30 m
Length between perpendiculars	84.00 m
Moulded breadth	14.71 m
Moulded depth	7.62 m
Engine	MAN B&W 4L35MCE
Total power	1692 kW
Crew	10

APPENDIX C: SOURCES AND SUBMISSIONS

Sources of information

Master and crew of *Baltimar Boreas*

Lloyd's Register

Australian Maritime Safety Authority

Wartsila NSD Australia

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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 *Baltimar Boreas*'s master, second mate, chief engineer and second engineer, Baltimar A/S, Lloyd's Register, Wartsila NSD Australia, the Australian Maritime Safety Authority and the Bahamas Maritime Authority.

Submissions were received from Lloyds Register, Wartsila NSD Australia, the Australian Maritime Safety Authority and the Bahamas Maritime Authority. The submissions have been included and/or the text of the report was amended where appropriate.

APPENDIX D: MEDIA RELEASE

ATSB final investigation report on ship fire off Newcastle

The ATSB has found that the engine room fire on board the general cargo ship *Baltimar Boreas* off Newcastle, on 9 February 2007, started after diesel oil leaking from a failed fuel hose on one of the ship's generator engines ignited.

The Australian Transport Safety Bureau investigation found that long term wear from chafing caused the flexible fuel hose to fail. Inadequate maintenance, use of longer than specified hoses and temporary repairs contributed to the poor condition of a number of hoses on the ship's generators. The length of the fuel hoses, as designed, was also not consistent with internationally-prescribed guidelines. The condition of the hoses had not been noticed during previous surveys, audits or inspections. The investigation also found that the ship's funnel ventilator closing arrangements were not in accordance with the intent of the relevant international regulations.

At 2305 on 8 February, the Bahamas registered *Baltimar Boreas* sailed from Newcastle with a cargo that included 945 tonnes of the industrial explosive, ammonium nitrate.

At 0250 on 9 February, the ship's fire detection system indicated a fire the engine room. On investigation, the second engineer found a large fire on number three generator. He quickly raised the alarm and stopped the engine room ventilation fans. The crew mustered quickly, operated systems to stop the engine room oil pumps and prepared to fight the fire. All the engine room ventilators were closed, except those at the top of the funnel which were inaccessible because of thick smoke and sparks issuing from them.

At 0305, Halon gas from the engine room fixed fire extinguishing system was released and the master then sent a distress message. A rapid response to the incident ashore was coordinated by the Australian Maritime Safety Authority. *Baltimar Boreas* was about five miles off the coast and a passing ship stood by to assist if necessary. A tug from Newcastle, with fire-fighting capability, was also sent to assist.

At 0340, the ship's crew determined that the fire was extinguished. There were no injuries but fire damage in the engine room had disabled the ship. By 1030, the tug had taken *Baltimar Boreas* in tow and the ship berthed in Newcastle for repairs later that day.

The ATSB has issued a number of recommendations and safety advisory notices with the aim of preventing similar incidents in the future.