Australian Government

Australian Transport Safety Bureau

ATSB TRANSPORT SAFETY INVESTIGATION REPORT

Marine Occurrence Investigation No. 215

Final

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

Java Sea

in Cairns, Queensland

24 May 2005

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Abstract

At about 0540 on 24 May 2005, a fire started on board the Singapore registered general cargo ship *Java Sea* while it was berthed in Cairns. The fire started in the engine room adjacent to the oil-fired thermal fluid heater, at deck level, under the poop in way of the aft peak bulkhead.

Initial attempts by the ship's crew to fight the fire using a fire hose were unsuccessful and the decision was taken to use the engine room Halon 1301 fixed fire extinguishing system. The release of the Halon 1301 proved ineffective, primarily because of the inability of the crew to close the dampers on the ventilation openings at the top of the funnel casing.

The fire was finally extinguished by the Queensland Fire Service, using high expansion foam injected through a hole cut in the base of the funnel at poop deck level directly above the seat of the fire.

The engine room and accommodation were significantly damaged by the fire and the associated fire fighting activities, to such an extent that *Java Sea* had to be towed to Singapore for permanent repairs.

The report found that it is probable a leakage of hot pressurised thermal fluid (mineral oil), possibly in the form of a spray, ignited when it came into contact with an un-lagged section of the oil-fired thermal fluid heater exhaust piping; and once started, the fire was fuelled by the contents of the thermal fluid expansion tank, the main engine cylinder oil service tank and the stern tube lubricating oil tank.

The report identifies a number of contributing factors and makes recommendations to address them.

THE AUSTRALIAN TRANSPORT SAFETY BUREAU

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The ATSB is responsible for investigating accidents and other transport safety matters involving civil aviation, marine and rail operations in Australia that fall within Commonwealth jurisdiction, as well as participating in overseas investigations involving Australian registered aircraft and ships. A primary concern is the safety of commercial transport, with particular regard to fare-paying passenger operations. Accordingly, the ATSB also conducts investigations and studies of the transport system to identify underlying factors and trends that have the potential to adversely affect safety.

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1 EXECUTIVE SUMMARY

At about 0540 on 24 May 2005, a fire started on board the Singapore registered general cargo ship *Java Sea* while it was berthed in Cairns. The fire started in the engine room adjacent to the oil-fired thermal fluid heater, at deck level, under the poop in way of the aft peak bulkhead.

Initial attempts by the ship's crew to fight the fire using a fire hose were unsuccessful and the decision was made to use the engine room Halon 1301 fixed fire extinguishing system. The release of the Halon 1301 proved ineffective.

The fire was finally extinguished by the Queensland Fire Service, using high expansion foam injected through a hole cut in the base of the funnel at poop deck level directly above the seat of the fire.

The engine room and accommodation were significantly damaged by the fire and the associated fire fighting activities, to such an extent that *Java Sea* had to be towed to Singapore for permanent repairs.

The investigation found that:

- It is probable that a leakage of hot pressurised thermal fluid (mineral oil), possibly in the form of a spray, ignited when it came into contact with an un-lagged section of the oil-fired thermal fluid heater exhaust piping.
- Once started, the fire was fuelled by the contents of the thermal fluid expansion tank, the main engine cylinder oil service tank and the stern tube lubricating oil tank.
- The engine room Halon 1301 fixed fire extinguishing system was ineffective in extinguishing the fire, primarily because of the crew's inability to close the funnel ventilation dampers.
- There were no operations, maintenance or emergency procedure manuals available on board *Java Sea* outlining the hazards associated with the ship's thermal fluid system.
- Without the prompt and effective assistance of the Queensland Fire Service it is likely that the damage to the ship, and the associated risks to its crew, would have been worse.
- The ship's crew had not recorded or carried out routine inspection and testing of safety equipment consistent with the ship's safety management system requirements.

The report recommends that:

- Ship owners, managers and masters should ensure that operations, maintenance and emergency procedure manuals are provided on board their ships for all critical equipment so that responsible personnel can familiarise themselves with any hazards associated with the equipment.

- Ship owners, managers and masters of ships with ventilation openings in funnel casings which have similar closing arrangements to those on board *Java Sea*, should assess their adequacy in consultation with the ship's classification society and Flag State administration.

2 FACTUAL INFORMATION

2.1 *Java Sea*

Java Sea is a Singapore registered, general cargo/container ship, owned by Gulf South Shipping and managed by Dobson Fleet Management, Limassol, Cyprus. The ship was classed with Lloyds Register (LR) and chartered by Freeport Mining.

The ship was built in 1988 by Zonghua Shipyard, Shanghai, China, launched as *Baltimar Jupiter* and re-named *Java Sea* in 1996. It has an overall length of 91.00 m, a moulded breadth of 14.70 m, a moulded depth of 7.60 m and a deadweight of 3168 tonnes at its summer draft of 4.971 m.

Figure 1: *Java Sea* berthed in Cairns

Java Sea can carry a variety of cargos and has a container capacity of 256 TEU[1]. The ship has a single hold located forward of the accommodation superstructure, which can be partitioned, served by two hydraulic cargo cranes. At the time of the incident *Java Sea* was operating a regular service between Cairns, Australia and Amamapare in West Papua, Indonesia.

Main propulsion power is provided by a single MAN B&W 4L35MC/MCE four cylinder, single acting, direct reversing, two-stroke diesel engine developing 1691 kW and driving a single fixed pitch propeller. The ship has a service speed of 13 knots.

1 Twenty-foot Equivalent Unit, the term for a 20 ft container. The nominal size of ships in TEU refers to the number of twenty-foot containers that may be carried.

The ship's engine room is equipped for unattended machinery space (UMS) operation, and fitted with a Halon 1301 fixed fire extinguishing system and a fire detection and alarm system.

At the time of the incident, *Java Sea* had a complement of 12, consisting of 11 Filipinos and one Indonesian national. When at sea, the mates and engineers maintain a watchkeeping routine of four hours on, eight hours off. While at anchor or in port, the mates continue their watchkeeping routine while the engineers work during the day with one engineer on call at night.

The master had over 30 years of seagoing experience, with nine years in command. He held a master class one certificate of competency, issued in the Philippines. He had served as master on board *Java Sea* for three contracts over the previous three years. He joined the ship on 22 March 2005, one month prior to the incident.

The chief engineer had about 30 years experience on a variety of ships. He held a class one certificate of competency, issued in the Philippines. His first contract as chief engineer on board *Java Sea* was from May till December 2004 and he had re-joined the ship as chief engineer on 21 April 2005.

2.1.1 Thermal fluid system

Java Sea relies on a thermal fluid system to generate and distribute heat around the engine room in order to warm fuel, lubricating and waste oil as necessary for the purposes of pumping, purification and use in the main propulsion machinery. Thermal fluid systems provide an alternative to the more common steam heating systems used on board most ships. Thermal fluid systems are generally cheaper to install and maintain than conventional steam heating systems.

The thermal fluid in use on board *Java Sea*, according to the manufacturer's product data sheet, was a high quality mineral oil suitable for use in closed liquid phase heating systems operating at temperatures of up to 320°C. It has a flash point[2] of 210°C and an auto-ignition[3] temperature of 350°C.

Heat for *Java Sea*'s thermal fluid system is derived from an exhaust gas heat exchanger located in the funnel. The heat exchanger extracts heat from the main engine exhaust gases and transfers it to the thermal fluid. When the main engine is not operating, a separate oil-fired thermal fluid heater located just forward of the engine room/aft peak bulkhead, at deck level under the poop, is used to maintain the temperature of the thermal fluid. The thermal fluid heater has a heavy fuel oil-fired rotary cup burner located on its roof. Diesel oil is used to establish a pilot flame as the first step in the burner start up sequence. This provides a flame to ignite the heavy fuel oil, which is atomised by the rotary cup. Once the heavy fuel oil flame is established, a photo-electric flame sensor shuts off the diesel oil supply to the pilot burner.

When in use, the oil-fired thermal fluid heater operates in automatic mode. The control unit monitors and maintains the temperature of the thermal fluid at a pre-determined set point by automatically starting and stopping the burner as

2 The lowest temperature at which the vapours from a volatile oil will ignite in air when exposed to a flame.

3 The ignition of the fuel/air mixture due to heat without the introduction of a flame.

necessary. The control system is mounted in a cabinet that is located directly adjacent to the port side of the oil-fired thermal heater.

The system's thermal fluid expansion tank sits directly under the base of the ship's funnel, and is located on the centre line at the after end of the engine room.

2.1.2 Halon 1301 fixed fire extinguishing system

Bromotrifluromethane, otherwise known as Halon 1301, is heavier than air. It is a colourless and odourless gas that chemically reacts with the combustion process. It has excellent fire extinguishing properties. Halon 1301 first came into use on board ships in the 1960s, but has since been identified as an ozone depleting substance. The production of Halon 1301 ceased in 1994, as part of an international effort to protect the earth's ozone layer.

Singapore, the responsible Flag State administration for *Java Sea*, has not established a phase out date for existing Halon 1301 fixed fire extinguishing systems on board ships registered under the Singapore flag. Thus, existing systems may continue to be used as long as they remain serviceable.

Halon 1301 is stored as a liquefied, compressed gas in a similar manner to carbon dioxide. The advantages offered by Halon 1301 are that storage pressures are lower and relatively small concentrations by volume provide an effective extinguishing capability, provided the extinguishing concentration is reached quickly.

The concentration by volume of Halon 1301 used in machinery space fixed fire extinguishing systems is usually between four and a quarter per cent of the gross volume and seven per cent of the net volume of the space to be protected.

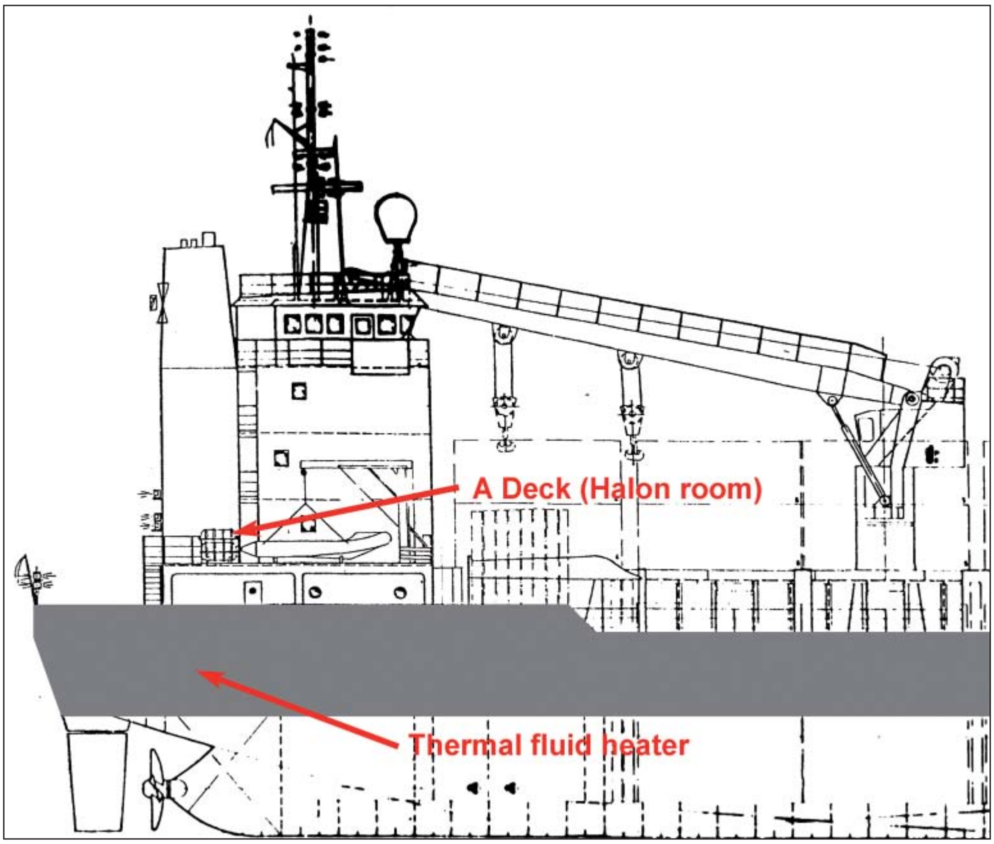
Figure 2: Halon 1301 storage cylinders

The extinguishing effectiveness of Halon 1301 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'. The release of Halon 1301 does not provide any cooling effect so there can be a danger of re-ignition if the space is ventilated too soon. Fixed fire extinguishing systems using Halon 1301 are only required to have sufficient storage capacity for one complete discharge of the total gaseous charge.

The Halon 1301 fixed fire extinguishing system fitted in *Java Sea*'s engine room comprised discharge nozzles and distribution piping supplied by four, separately located, and pneumatically operated gas cylinders. Each cylinder contained 67 litres of Halon 1301 at a storage pressure of 42 bar[4] (Figure 2).

The four cylinders are linked to ensure the simultaneous release of the total charge of the extinguishing agent and the whole system can be operated remotely from the halon room, located on the port side of A deck (Figure 3).

Figure 3: Plan of the ship



In addition to the system controls, the halon room also contains the remote stops for the fuel oil and other pumps discharging flammable liquids, the oil-fired thermal fluid heater forced draught fan and purifiers located in the machinery space. The halon room also contains the controls for the various engine room fuel, lubricating and flammable oil tank quick closing valves. The ventilation fans for the engine room shut down automatically on operation of the halon system.

4 1 bar = 100 KPa (approximately one atmosphere).

A sign in the halon room on board *Java Sea* describing how to operate the engine room fixed fire extinguishing system included the instruction 'Close all openings shut off fuel oil supply'.

2.1.3 Fire detection and alarm system

The main control panel of *Java Sea*'s fire detection and alarm system is located on the bridge (Figure 4). The system is divided into eight independent detection 'loops' covering the various decks or areas of the ship. Each loop comprises a number of heat and smoke activated sensors, together with a push button to manually initiate a fire alarm.

Figure 4: Bridge fire alarm control panel

2.2 The incident

At 1930[5] on 22 May 2005, *Java Sea* was secured port side to at number seven berth in Cairns harbour after completing a voyage from Amampare.

The next morning the stevedores commenced discharging cargo and at 1200, with unloading completed, the loading of the northbound cargo commenced. At 1748, cargo operations finished for the day with 78 TEU loaded on board. The ship remained alongside the berth to await completion of loading before the scheduled sailing time of 1600 on 24 May.

The mates and seamen on board *Java Sea* maintained their usual pattern of port watches. The seamen on watch during the night made periodic safety and security rounds and adjusted the gangway and mooring lines as required. The engineers

5 All times referred to in this report are in local time, coordinated universal time (UTC) + 10 hours.

worked during the day, and the second engineer was the nominated duty engineer from midday 23 May until midday 24 May.

During the evening of 23 May, the second engineer responded to engine room alarms at about 2100 and again at about 2300. On both occasions the alarm indicated low viscosity in the fuel oil system. As the ship was not underway, the heavy oil-fired thermal fluid heater was in use. On each occasion the engineer found that the oil-fired thermal fluid heater burner had failed to automatically ignite.

At 0520 on 24 May, the second engineer responded to another alarm. The engine room alarm panel indicated a fire on loop five (the galley and poop deck area). He checked these locations, but could find no indication of a fire. He then checked all the other detectors in the circuit on the upper deck level, but found no sign of fire.

On returning to the engine room, the second engineer requested that the chief mate, who was on the bridge at the time, reset the fire detection and alarm system. At 0530, after finishing his checks, the second engineer went to the mess room.

At about 0540 the engine room alarm sounded again. The second engineer returned to the engine room and checked the alarm panel, which was now showing 'central heating boiler failure'. The alarm would not reset and a second alarm 'thermal oil boiler failure' quickly followed. To investigate the alarms further the second engineer went to the oil-fired thermal fluid heater control cabinet. As he approached the area, he saw flames and smoke at the bulkhead immediately aft of the oil-fired thermal fluid heater control panel.

The second engineer immediately ran out of the engine room shouting, 'Fire! Fire!' to raise the alarm. He also stopped the engine room ventilation fans as he left the engine room. When he arrived at the upper deck he was met by the duty seaman, who immediately activated the ship's fire alarm by operating a manual push button in the upper deck alleyway. The ship's fire alarm sounded at 0541. The second engineer went to his muster station on the aft deck and the duty seaman made his way to the bridge to report to the master.

The third engineer, after waking to the fire alarm went to his muster station on the aft deck, before going to the engine room where he met the chief engineer. Together the two men ran out a fire hose and attempted to fight the fire, but left the engine room when it became apparent that the fire was beyond their control.

The master was also woken by the fire alarm and went directly to the bridge, where he was joined by the duty seaman and the second mate.

The chief mate, who had gone down to his cabin after earlier resetting the fire alarm system, returned to the bridge when the fire alarm sounded. After speaking briefly with the master he went to the aft deck muster station to co-ordinate fire fighting activities. He assembled the crew at the muster station on the aft deck and accounted for all crew members. He received various reports relating to the closing of ventilation flaps around the accommodation block and he also started boundary cooling of the funnel.

The second mate started the ship's engine room fire pump from the bridge. The duty seaman checked that the ventilation fans for the engine room and accommodation had been stopped. In an attempt to raise the alarm with the local fire authorities, the duty seaman went ashore to activate the fire alarm push button located on the wharf near the end of the gangway. He then returned on board to assist with the fire fighting activities.

The master, assisted by the second mate, called Cairns Harbour Control on the ship's very high frequency (VHF) radio to report the fire and to request assistance. Cairns Harbour Control acknowledged the call and then moved to establish an exclusion zone around the ship. The master could see that there was smoke and flames jetting out of the large ventilation openings at the top of the funnel casing. He realised that the manually operated dampers on these openings should be closed but he thought that the amount of heat and smoke being produced by the fire would make closing them impossible.

The master called the chief mate using a hand held ultra high frequency (UHF) radio and ordered him to operate the engine room Halon 1301 fixed fire extinguishing system. The master then repeated this command by yelling from the bridge wing to the crew on the deck below. The chief engineer heard the command from the master and went to the halon room and activated the system.

At 0552, the Queensland Fire Service (QFS) arrived on the wharf. The fire fighters took control of the scene, evacuated the ship and continued fighting the fire.

After an examination of the ship's plans and in consultation with the master, the QFS decided that they would cut a hole in the base of the funnel at the poop deck level to allow high expansion foam to be pumped directly into the engine room, above the seat of the fire.

The high expansion foam was successful in extinguishing the fire and at 0700 the fire was declared extinguished. At 1230 on 24 May, control of the ship was handed back to the master.

A preliminary inspection of the ship on 25 May revealed severe fire damage to both the oil-fired and exhaust gas thermal heating units, associated circulating pumps, control equipment, piping and electrical cabling at the after end of the engine room. The main switchboard was also damaged as were various pumps and equipment at the engine room floor plate level, primarily by the foam and water used to fight the fire. The two lower decks of the ship's accommodation were severely damaged by heat, smoke and water. The ship's classification was subsequently suspended and *Java Sea* was towed to Singapore for permanent repairs.

3 ANALYSIS

3.1 Evidence

On 25 May 2005, two investigators from the Australian Transport Safety Bureau (ATSB) attended *Java Sea* in Cairns. The investigators carried out a preliminary examination of the ship and after it was moved to a nearby berth, and a shore supply of electrical power connected, a more thorough investigation of the scene of the fire was carried out.

The evidence indicated a low spread, high intensity fire, causing major damage to the first level of the aft section of the engine room, extending upwards into the funnel casing (Figure 5). The thermal fluid head tank and main engine cylinder oil service tank located in the vicinity were burnt out. Smoke and radiant heat damage was confined to the engine room upper level, the main switchboard and local electrical cables, and the first and second levels of accommodation immediately adjacent to the fire (Figure 6).

Figure 5: Funnel casing ventilation openings and closing dampers

Figure 6: Damage to accommodation alley way

The main engine exhaust heat-exchanger, the oil-fired thermal fluid heater and the associated circulating pumps, piping and control cabinet (Figure 7) were extensively damaged. This made an objective assessment of the exact cause of the fire difficult.

Figure 7: The remains of the oil-fired thermal fluid heater control cabinet

The master and directly involved crew members were interviewed and provided their accounts of the incident. Copies of relevant documents were obtained including log book entries, statutory certificates, plans, manuals and procedures.

Information was also gathered from the Cairns Port Authority, the ship's local agent, the Australian Maritime Safety Authority (AMSA), Lloyds Register (LR), the Queensland Police Service (QPS) and the Queensland Fire Service (QFS).

3.2 The fire

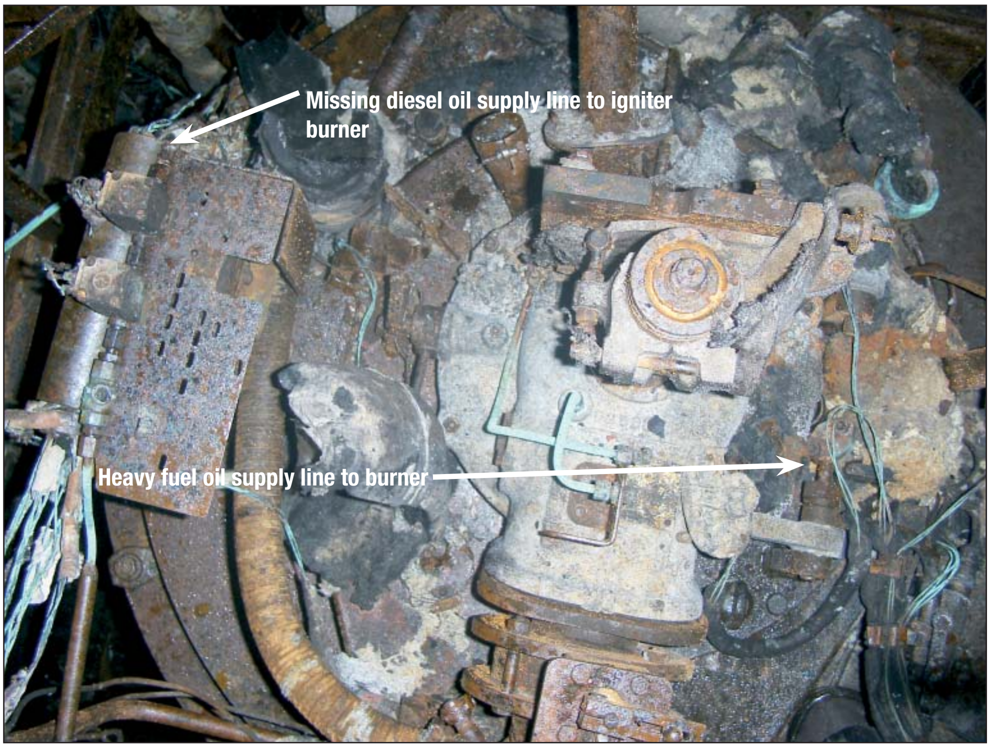
The fire started in an area aft of the oil-fired thermal fluid heater, at deck level under the poop, in way of the aft peak bulkhead, at about 0540 on 24 May. Despite initial attempts by the crew to fight the fire using a fire hose they were quickly overwhelmed, and the master made the decision to use the engine room Halon 1301 fixed fire extinguishing system. The Halon 1301 proved ineffective, primarily because the dampers on the ventilation openings at the top of the funnel casing were left open (Figure 5).

3.2.1 Sources of fuel

Diesel and heavy fuel oil

It is possible that one of the diesel oil or heavy fuel oil pipes or seals in the supply systems for the oil-fired thermal fluid heater burner unit may have been damaged and leaking (Figure 8). The steel heavy fuel supply line for the burner was fitted with a rotary union to allow the burner assembly to be withdrawn from the top of the boiler. The union is subject to repeated wear during maintenance and therefore

Figure 8: Top of the oil-fired thermal fluid heater



it is a potential source of fuel leakage. Similarly, the flexible fuel line between the diesel pilot burner assembly and the diesel supply shut off solenoids would have been subjected to a high rate of wear due to regular removal of the pilot burner assembly to service its fuel nozzle and igniters. Flexible fuel pipes subject to similar conditions of service have been responsible for a number of fires in the past and must be replaced on a regular basis to ensure that they do not leak as a result of maintenance related mechanical damage.

Had one of these pipes or seals been leaking it is probable that the fuel would have accumulated for a time and then run off the top of the oil-fired thermal fluid heater. The trim of the ship would have directed the leaking fuel towards the back of the heater. Eventually the fuel would have pooled at deck level behind the heater, the area that was identified as the seat of the fire.

It is possible that the thermal fluid heater flame failures which occurred at 2100 and 2300 the evening before the fire may have been related to a diesel leak on the supply line for the pilot burner. If there had been a small leak it may have led to the pilot flame failing intermittently and thus the alarms the second engineer attended to the previous evening. In the hours which followed, each time the automatic controls initiated the burner lighting sequence more and more diesel may have been accumulating on the top of the heater. The second engineer stated that he had reset the burner automatic control system which had rectified the problem each time. The top of the heater and the burner assembly would not have been readily visible from where the engineer was standing at the control cabinet which meant that he would not necessarily have seen a leak. However, any diesel lying on the top of the heater would have been quite hot and thus creating fumes which the engineer should have noticed.

In addition to the thermal fluid heater burner fuel systems, there was also a number of heavy fuel oil pipes located on the bulkhead immediately aft of the heater. A leak from any of these pipes would have led to fuel pooling at deck level in the area where the fire started.

Thermal fluid

Thermal fluid systems on board ships present a potential fire hazard because of the large volume of relatively high temperature combustible mineral oil circulating throughout these systems. The hot thermal fluid is easily ignited if accidentally released and there are large volumes of thermal fluid available to fuel a fire. Although relatively few fires have originated in thermal fluid systems, there are four main areas of risk; fluid soaked insulation, loss of fluid flow, cracked oil-fired thermal heater tubes and large volume external leaks.

Insulation fires can occur when thermal fluid leaks from valves, gaskets, flange joints, welds or instrument ports, and impregnates the porous insulation material. The open structure of the insulation material allows the thermal fluid to 'wick away' from the leak and spread throughout the insulation. The hot thermal fluid, coming into immediate contact with the air contained in the insulation's micro structure can oxidize and decompose, in the process consuming the existing air and creating more heat. Confined within the insulation and having little chance of escaping, oxidation continues to cause the thermal fluid to rise in temperature and in some cases beyond the point of auto-ignition. Should the insulation's protective covering be punctured or damaged, fresh air will immediately enter. When the air comes into contact with the hot, partially oxidized thermal fluid, the thermal fluid can spontaneously ignite.

Loss of flow can occur when the circulation of thermal fluid through the heater is interrupted. The failure of a circulation pump, pressure control valve or a partially blocked filter may cause a loss of fluid flow and a subsequent increase in fluid temperature. If the heater high temperature cut-off device does not respond promptly to the temperature increase, the heat energy continues to be transferred to the near stationary fluid. The fluid temperature may increase beyond that required for auto-ignition. If a crack develops in a heater tube or the associated piping system, the hot thermal fluid will be discharged into the surrounding atmosphere where it may ignite spontaneously.

Serious fires caused by cracked oil-fired thermal heater tubes are relatively rare. Cracks are formed by excessive thermal cycling or at hot spots that can develop from internal fouling or flame impingement. Leaking fluid will burn off when the heater is operating, but if not; the thermal fluid is likely to leak into the combustion chamber and pool inside; igniting once the heater is re-started.

Large volume leakage from a thermal fluid system can be a direct cause of fire if the hot fluid comes into contact with an ignition source. Most major leaks result from component failure. Expansion joints, flexible hoses, instrument ports and rotary unions are amongst those more likely to fail, and if an ignition source is directly adjacent to the leaking fluid, a serious fire may occur.

There were a number of thermal fluid circulating and trace heating pipes located on the bulkhead immediately aft of *Java Sea*'s oil-fired thermal fluid heater. Any one of these pipes or their associated pressure gauge or flow switch lines (Figures 9 and 10) may have developed a leak, which would have led to a relatively large volume of hot thermal fluid, under pressure, escaping from the system in a short period of time.

In addition, the thermal fluid head tank was located directly above the oil-fired thermal fluid heater. While the outlet of the tank was fitted with a quick closing valve, the remote operating system for the engine room quick closing valves was not actuated by the ship's crew at any time during the fire. As a result, it is probable that the contents of the header tank continued to fuel the fire once it had started.

An inspection of the area following the fire revealed that a flanged coupling in the head tank's outlet line was leaking. The coupling was located directly over the top of the oil-fired thermal oil heater and it appeared that at some point the fire had been hot enough to deform the bolts holding the flanges of the coupling together. At this point, with the quick closing valve open, any oil left in the tank would have flowed out of the coupling directly onto the seat of the fire.

Figures 9: Thermal fluid piping and instrument ports

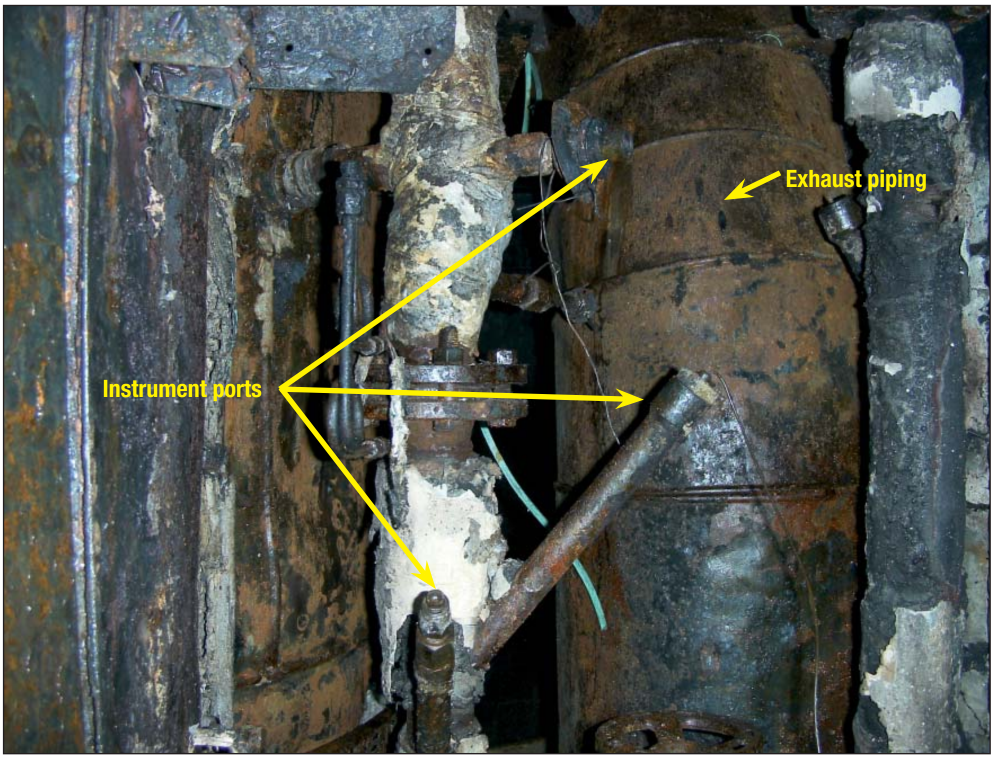
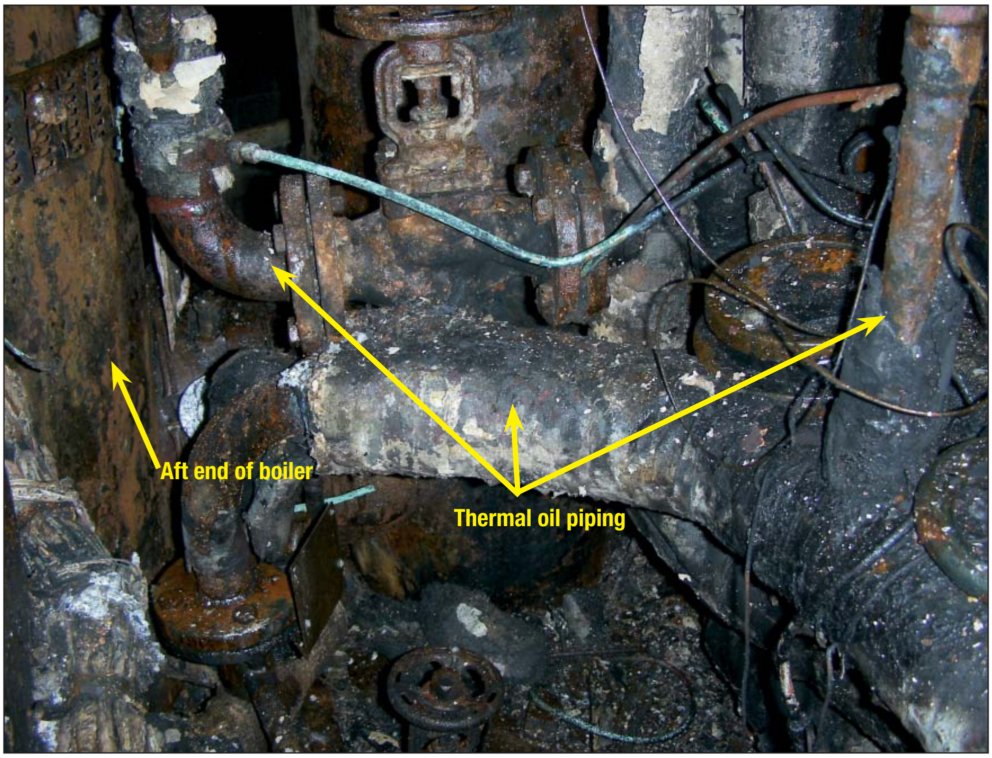


Figure 10: Thermal fluid piping



Lubricating oil

The main engine cylinder oil service and stern tube header tanks were located adjacent to the top of the oil-fired thermal heater and were in the flame path directly above the seat of the fire. The heat of the fire had melted the gauge glasses on both tanks and the valves isolating the gauge glasses were found to be gagged open. While it is unlikely that these tanks were the source of the fuel that started the fire, once the gauge glasses had failed during the fire, most of the lubricating oil in the tanks would have drained out through the damaged sight glasses and helped fuel the fire.

A Port State Control (PSC) inspection of the ship carried out by AMSA on 28 January 2005, identified the gagged oil tank gauge glass cocks on board *Java Sea*. However, having this deficiency raised had not heightened the crew's awareness of the dangers of this practice, as the valves were again gagged on 24 May 2005.

Conclusion

A diesel leak from the pilot burner on the oil-fired thermal fluid heater or a leak of hot thermal fluid from one of the pipes at the back of the heater are the two most likely sources of the fuel that initiated the fire. Based on the location of the seat of the fire, its intensity and the speed at which it took hold, it is probable that the initial fuel source was a leakage of hot, pressurised, thermal fluid. Thermal fluid under pressure would have continued to feed the fire until such time as the thermal fluid circulating pumps were stopped, and this did not occur until the running generator stopped, well after the time that the Halon 1301 had been released into the engine room. By this time the fire was well beyond the control of the ship's crew.

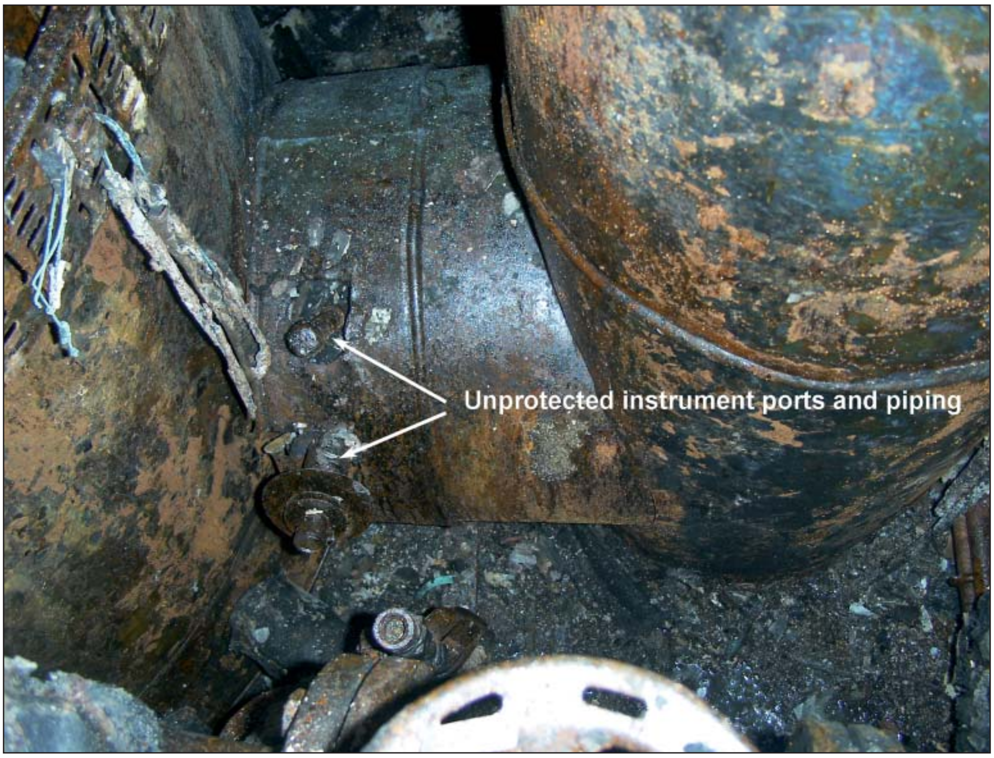
There were several other sources of fuel which would have continued to feed the fire even after the thermal fluid circulating pumps had stopped. The failure of the crew to actuate the remote release for the quick closing valves meant that the thermal fluid in the system's head tank would have continued to flow out of any leak under gravity thereby feeding the fire. Once the heat of the fire caused the failure of the gauge glasses fitted to the nearby main engine cylinder oil service and stern tube lubricating oil head tanks, the contents of these tanks would have also fed the fire.

3.2.2 Sources of ignition

There were at least two potential sources of ignition in the area adjacent to the oil-fired thermal fluid heater where the fire started; the exhaust piping and the heater control cabinet.

Combustion gases leave the oil-fired thermal fluid heater just above deck level through exhaust piping that leads to the funnel. There were instrument ports fitted in the exhaust piping, and these ports and the exhaust piping surrounding them was not protected by any insulation or metal cladding (Figure 11). With the burner firing, the temperature of the steel instrument ports would have approached that of the heater exhaust gases (250 to 300° C), well above the flash point of either diesel oil or thermal fluid.

Figure 11: Oil-fired thermal fluid heater exhaust piping indicating the unprotected instrument ports



A leak from one of the thermal fluid pipes adjacent to the heater, particularly a spray from an instrument port or gauge line fitting, would probably have impinged on the hot exhaust piping and ignited. Similarly, if fuel had leaked from the burner fuel lines it may have accumulated on the top of the heater and eventually run down the side of the heater, at it's after end, directly onto the unprotected sections of the hot exhaust piping.

It is also possible that leaking thermal fluid may have sprayed into the oil-fired thermal fluid heater control cabinet via one of the cooling openings in the side cabinet. Once inside the cabinet, the thermal fluid may have been ignited by electrical sparking from a contactor, relay, the cabinet's cooling fan motors or through direct contact with an overheated component. While this scenario is much less likely than ignition from the heater exhaust uptake, it would explain why the control cabinet was completely burnt out (Figure 7). However, it is also possible that the cabinet doors were left ajar and that the components inside the cabinet were completely incinerated at a latter stage in the fire and were not the source of ignition.

While it was not possible to conclusively identify the source of ignition, the most likely scenario is that leaking thermal fluid came into contact with the hot, unprotected sections of the oil-fired thermal fluid heater's exhaust piping.

3.3 Thermal fluid system maintenance

There were no specific operations, maintenance or emergency procedure manuals on board *Java Sea* for the thermal fluid system. The limited information that was available indicated that the operating pressure of the system was about five to six bar with a working temperature of 130 to 150ºC.

The ship's safety management system required daily testing of the oil-fired thermal fluid heater low oil level and flame failure alarms, and shut downs. The records of this testing indicated that it had last been carried out in November 2004.

The oil-fired thermal fluid heater had been surveyed on 13/14 April 2005, when it had been examined under normal operating conditions. All shut downs and alarms were tested at this time and found to operate satisfactorily.

An intermittent problem affecting the control of the oil-fired thermal fluid heater had recently developed. This problem was traced to a faulty electronic card. The fault caused the oil-fired thermal fluid heater to occasionally fail to ignite automatically. The failure of the burner to ignite led to the thermal fluid temperature falling to a point where the heat transfer to the main engine fuel oil system dropped off enough to activate the fuel oil viscosity alarm. On receiving an alarm the duty engineer would reset the burner controls to restart it and the burner would fire until the thermal fluid was up to temperature, before stopping automatically. This intermittent fault may well have been the cause of the alarms the second engineer responded to at 2100 and 2300 on the evening before the fire.

The crew's lack of attentiveness to the routine checking of the critical oil-fired thermal heater alarms indicates a general lack of system awareness, and without manuals covering operation, maintenance and emergency procedures for the thermal oil system, they were not able to adequately familiarise themselves with the system.

3.4 Emergency response

Java Sea's crew had practiced fire fighting during drills on board the ship. The last emergency drill held before the incident was on 5 May 2005, when the master chose to simulate a fire in the engine room that eventually became uncontrollable. The crew were also instructed in the operation of the engine room Halon 1301 fixed fire extinguishing system as part of the drill.

The first attempt at fighting the fire on 24 May 2005 was made by the chief engineer and the third engineer using a fire hose. The use of portable extinguishers was considered, but the size of the fire and the amount of heat and smoke being generated, even at this early stage of the fire's development, did not allow the two men to get close enough to discharge extinguishers directly onto the seat of the fire. The two men quickly decided that the fire was beyond their control and retreated, but only after having identified the location of the fire.

The chief engineer informed the master of the fire's intensity, and that it could not be extinguished using hoses or extinguishers. The master, seeing the amount of smoke and flames jetting from the funnel ventilation openings decided that the dampers on these openings could not be closed and that the fire was rapidly building in intensity. He then ordered the chief engineer to operate the engine room Halon 1301 fixed fire extinguishing system.

The chief engineer, following the master's instructions, activated the engine room Halon 1301 fixed fire extinguishing system. However he did not follow the operating instructions posted in the halon room. He did not shut off the fuel supply by actuating the engine room oil tank quick closing valves and stopping the running fuel and lubricating oil pumps, and he did not ensure that all ventilation openings were closed.

The Queensland Fire Service (QFS) arrived within 11 minutes of the ship's fire alarm sounding, in direct response to the duty seaman operating the shore side push button fire alarm. They took over boundary cooling of the aft end of the ship's accommodation and the funnel area while assessing the situation prior to assuming total control.

The QFS decided to evacuate *Java Sea*'s crew, but before doing so, the ship suffered a loss of electrical power and blacked out, probably as a consequence of damage sustained to the main switchboard and associated electrical cabling during the fire. The ship's crew were safely evacuated and accounted for, but they did not consider starting the emergency generator or the emergency fire pump. They did not attempt to pressurise the ship's fire main to assist the QFS in their efforts to bring the fire under control.

After consultation with the master, the QFS decided to introduce high expansion foam through the base of the funnel casing directly above the seat of the fire. The high expansion foam was instrumental in effectively extinguishing the fire. Without the decisive action of the QFS the damage to *Java Sea* would have been far worse, and the fire may have spread to the wharf and the adjoining port facilities. Had the ship been destroyed the wharf may have been out of service for some time while the wreckage was removed, and the impact on the local environment may have been widespread.

3.4.1 Ineffectiveness of Halon 1301 in extinguishing the fire

A combination of the open ventilation dampers on the upper funnel casing and the intensity of the fire had created a chimney effect that probably drew the Halon 1301 out of the machinery space almost as soon as it was released.

The SOLAS [6] requirements applicable to *Java Sea* at the time it 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' [7]

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

7 SOLAS 74, Chapter II-2, Regulation 11.

The dampers for the ventilation openings in the funnel casing were not capable of being closed remotely and it is now clear that under the circumstances which existed at the time, manual closure of the dampers was not possible. The location, intensity and rapid propagation of the fire led to flames and large amounts of heat and smoke escaping through the ventilation openings. This effectively cut off access to the dampers from the external platform fitted on the port side and aft around the funnel (Figure 5).

No attempt was made to activate the engine room quick closing valves, including the generator fuel supply, and as a result the number one diesel generator was still running when the Halon 1301 was released. The concentration of Halon 1301 in the engine room would have been depleted when Halon 1301 was drawn into the diesel generator's air intake. This loss of Halon 1301 would have been eliminated if the diesel generator had been shutdown before the release of the Halon 1301.

The failure to activate the engine room quick closing valves also had an impact on the size and intensity of the fire. The fire may not have been as intense if the quick closing valves had been activated soon after the fire began, as the amount of fuel available to feed the fire would have been reduced. The Halon 1301 may have been more effective in extinguishing a less intense fire.

3.4.2 Maintenance and testing of emergency equipment

The ship's safety management system required weekly checks of all ventilation flaps and dampers and monthly operation of the engine room oil tank quick closing valves. The records indicate that these tests were last carried out in November 2004.

The last annual safety equipment survey carried out on board *Java Sea* in Cairns on 18 January 2005 indicated that the Halon 1301 fixed fire extinguishing system had been recently serviced by an approved service provider. The operation of the closing arrangements for the funnel and ventilation openings, remote stops, and the engine room oil tank quick closing valves was confirmed at this time.

3.4.3 Evacuation at sea

It is probable that the damage to the ship and the associated risk to its crew would have been far more severe if the incident had occurred away from the port, where the assistance of the shore-based fire services would not have been available. If the fire had occurred while the ship was at sea or at anchor, the limited options available to the crew in fighting the fire following the unsuccessful discharge of the Halon 1301 would have probably resulted in the ship being abandoned.

Java Sea was equipped with a rescue boat and four inflatable life rafts, with the rescue boat to be used to retrieve persons from the water, marshal the rafts and then tow them clear of the abandoned ship. Two of these life rafts were situated on the starboard side of 'A' deck alongside the funnel casing. The rescue boat was positioned just forward of these two life rafts and adjacent to the accommodation (Figure 3). Given the location of the fire and its heat and intensity, these life saving appliances probably would not have been accessible to the crew if there was a need to abandon the ship.

4 FINDINGS

From the evidence available, the following findings are made with respect to the fire on board *Java Sea* on 24 May 2005 and should not be read as apportioning blame or liability to any particular organisation or individual.

4.1 Contributing safety factors

These findings identify the various events and conditions that increased safety risk and contributed to the incident.

1. It is probable that a leakage of hot pressurised thermal fluid (mineral oil), possibly in the form of a spray, ignited when it came into contact with an unprotected section of the oil-fired thermal fluid heater's exhaust piping.
2. Once started, the fire was further fuelled by the contents of the thermal fluid expansion tank, the main engine cylinder oil service tank and the stern tube lubricating oil tank.
3. The engine room Halon 1301 fixed fire extinguishing system was ineffective in extinguishing the fire because:
   - the ship's crew could not close the dampers on the ventilation openings at the top of the funnel casing;
   - the diesel generator was not shut down before the Halon 1301 was released;
   - the oil tank quick closing valves were not operated.

4.2 Other safety factors

These findings identify other events and conditions that increased safety risk.

1. There were no operations, maintenance or emergency procedure manuals available on board *Java Sea* outlining the hazards associated with the ship's thermal fluid system.
2. Without the prompt and effective assistance of the Queensland Fire Service it is likely that the damage to the ship, and the associated risks to its crew, would have been much worse.
3. The ship's crew had not recorded or carried out routine inspection and testing of safety equipment consistent with the ship's safety management system requirements.

5 SAFETY ACTIONS

5.1 ATSB recommendations

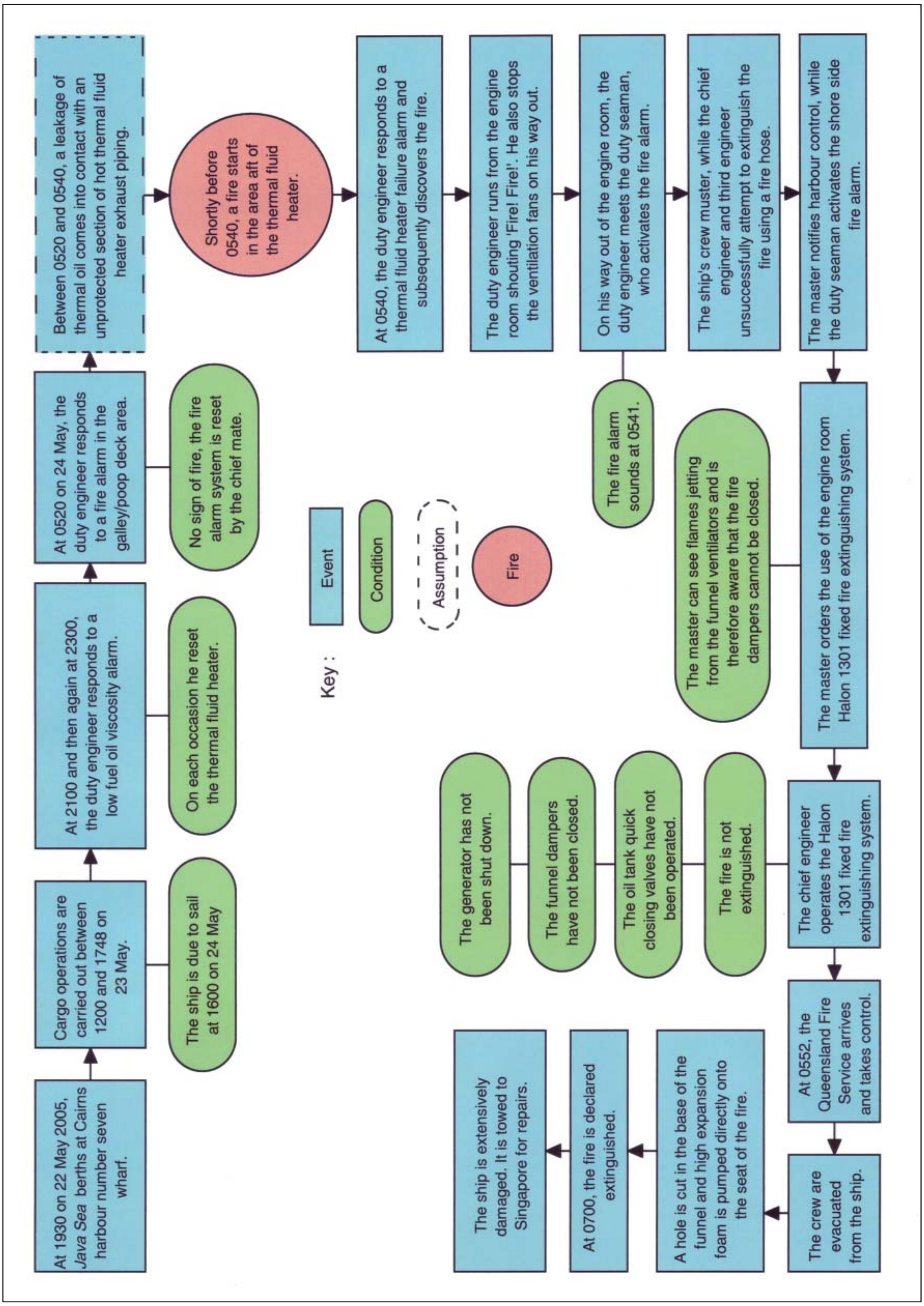
MR20060038

Ship owners, managers and masters should ensure that operations, maintenance and emergency procedure manuals are provided on board their ships for all critical equipment so that responsible personnel can familiarise themselves with any hazards associated with the equipment.

MR20060039

Ship owners, managers and masters of ships with ventilation openings in funnel casings which have similar closing arrangements to those on board *Java Sea* should assess their adequacy in consultation with the ship's classification society and Flag State administration.

6 APPENDIX A: EVENTS AND CONDITIONS



7 APPENDIX B: SHIP INFORMATION

7.1 *Java Sea*

IMO Number	8607684
Call sign	9V5361
Flag	Singapore
Port of Registry	Singapore
Classification society	Lloyds Register
Ship Type	General cargo / Multi purpose
Builder	Zonghua Shipyard, China
Year built	1988
Owners	Gulf South Shipping
Ship managers	Dobson Fleet Management, Limassol, Cyprus
Charterer	Freeport Mining
Gross tonnage	2854
Net tonnage	1094
Deadweight (summer)	3168.62 tonnes
Summer draught	4.97 m
Length overall	91.00 m
Moulded breadth	14.70 m
Moulded depth	7.60 m
Engine	MAN B&W 4L35MC/MCE
Total power	1691 kW
Service speed	13 knots
Crew	12

8 APPENDIX C: SOURCES AND SUBMISSIONS

8.1 Sources of information

The master and crew of *Java Sea*

Queensland Fire Service

Queensland Police Service

Lloyds Register

Maritime Safety Queensland

Australian Maritime Safety Authority

8.2 References

The International Convention for the Safety of Life at Sea, 1974, and its Protocol of 1988 (SOLAS), the International Maritime Organization.

8.3 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 *Java Sea*'s master, chief engineer, technical manager and P&I correspondent, Lloyds Register, Maritime Safety Queensland and the Australian Maritime Safety Authority.

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

9 APPENDIX D: MEDIA RELEASE

Shipboard fire in Cairns

The ATSB has found that a fire on board the Singapore registered ship *Java Sea* on 24 May 2005 started when hot pressurised thermal oil, possibly in the form of a spray, came into contact with an un-lagged section of the thermal oil heater exhaust piping. The fire was further fuelled by the contents of oil storage tanks located near the seat of the fire.

The Australian Transport Safety Bureau investigation found that the fixed fire extinguishing system was ineffective in extinguishing the fire because the ship's crew could not close the funnel casing ventilation dampers; the diesel generator was not shut down before the system was activated; and the oil tank quick closing valves were not operated.

At about 0540 on 24 May, a fire started in the engine room of the general cargo ship *Java Sea* while it was berthed in Cairns. Initial attempts by the ship's crew to fight the fire using a fire hose were unsuccessful and the decision was made to operate the engine room Halon 1301 fixed fire extinguishing system.

The release of the Halon 1301 proved ineffective. The fire was eventually extinguished by the Queensland Fire Service, using high expansion foam injected through a hole cut in the base of the funnel at poop deck level, directly above the seat of the fire.

There were no serious injuries as a result of the fire. However, the engine room and accommodation were significantly damaged by the fire and the associated fire fighting activities. The ship had to be towed to Singapore for permanent repairs.

The report makes recommendations to ship owners, managers and masters with reference to closing arrangements for funnel casing ventilation openings and on board maintenance and emergency procedure manuals.

Independent investigation into the engine room fire on board the Singapore registered general cargo ship *Java Sea* in Cairns, Queensland, 24 May 2006