



Australian Government

Australian Transport Safety Bureau



ATSB TRANSPORT SAFETY REPORT
Marine Occurrence Investigation No. 269
MO-2009-009
Final

Independent investigation into the steering gear compartment fire
on board the Marshall Islands registered anchor handling tug

Petra Frontier

at sea off Darwin, Northern Territory

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CONTENTS

DOCUMENT RETRIEVAL INFORMATION	v
THE AUSTRALIAN TRANSPORT SAFETY BUREAU	vii
TERMINOLOGY USED IN THIS REPORT	ix
EXECUTIVE SUMMARY	xi
1 FACTUAL INFORMATION	1
1.1 <i>Petra Frontier</i>	1
1.1.1 Steering gear compartment	2
1.2 The incident	3
2 ANALYSIS	11
2.1 Evidence	11
2.2 The fire	11
2.3 Fire alarms	14
2.4 Emergency response	15
2.4.1 Control and coordination	15
2.4.2 Breathing apparatus (BA) equipment	17
2.4.3 Emergency messages	17
2.5 Emergency preparedness	18
2.5.1 Crew induction.....	19
2.5.2 Drills and training	20
2.5.3 Inter-departmental relationships	21
2.6 Seaworthiness	22
2.7 Housekeeping	24
3 FINDINGS.....	25
3.1 Context	25
3.2 Contributing safety factors	25
3.3 Other safety factors.....	26
4 SAFETY ACTION.....	27
4.1 Petra Marine Australia.....	27
4.1.1 Drill schedule.....	27
4.2 American Bureau of Shipping	27
4.2.1 Seaworthiness	27
4.3 Marshall Islands Registry	28

4.3.1 Seaworthiness	28
APPENDIX A: EVENTS AND CONDITIONS.....	31
APPENDIX B: SHIP INFORMATION.....	33
APPENDIX C: SOURCES AND SUBMISSIONS.....	35

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Abstract

Shortly before 0540 on 28 September 2009, a fire started in the steering gear compartment of the Marshall Islands registered anchor handling tug supply vessel *Petra Frontier* while it was en route from the Timor Sea to Darwin, Northern Territory.

The ship's crew were unable to extinguish the fire using portable fire extinguishers. By about 0640, all of the compartment's access doors and vents were closed, the electrical power supply to the machinery in the space was isolated and the deck above was boundary cooled. As a result of these actions, the fire eventually burnt itself out.

The investigation found that the fire probably started when rags, which had been soaked in oil that was leaking from a hydraulic unit, were ignited by heat generated by, or a spark emanating from, an electrical solenoid. The investigation also found that the ship's crew had not identified the numerous deficiencies that existed in the ship's emergency equipment, they were not familiar with the use of the emergency equipment and the on board response to the fire was not well managed.

The investigation identified two safety issues: while *Petra Frontier* had undergone a series of flag State inspections and class surveys, neither authority was aware that the ship was unseaworthy in relation to critical safety equipment; and the ship's safety management system contained some contradictory information relating to the scheduling of fire and abandon ship drills.

THE AUSTRALIAN TRANSPORT SAFETY BUREAU

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

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

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

Purpose of safety investigations

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

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

Developing safety action

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

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

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

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

TERMINOLOGY USED IN THIS REPORT

Occurrence: accident or incident.

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

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

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

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

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

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

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

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

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

EXECUTIVE SUMMARY

Shortly before 0540¹ on 28 September 2009, while the Marshall Islands registered anchor handling tug supply vessel *Petra Frontier* was en route from the Timor Sea to Darwin, Northern Territory, an off duty integrated rating (IR) noticed what looked like a cloud of cement dust above the ship's port quarter². The IR went to the engine room to investigate and saw that there was smoke in the steering gear compartment. He then ran to the bridge to raise the alarm.

At 0540, the ship's muster signal was activated. The IR, the bridge lookout and the chief engineer then went to the steering gear compartment to further investigate the fire. However, the smoke was too thick so they closed the compartment access door and left. The chief engineer went to stop the ventilation fans while the IRs went to the main deck.

Meanwhile, the second mate and the remaining crew had mustered on the main deck. Two IRs donned breathing apparatus (BA) units in anticipation that they would be needed to fight the fire.

At 0558, a BA party entered the steering gear compartment in an attempt to extinguish the fire using portable fire extinguishers. However, before they could do so, a crew member told them evacuate the compartment in the belief that the ship's fixed carbon dioxide fire extinguishing system was going to be used to extinguish the fire.

After evacuating the engine room, the chief engineer and the first engineer started the emergency generator, operated the machinery remote stops and tripped the oil tank quick closing valves.

The master and the chief mate decided to isolate the air supply to the steering gear compartment and boundary cool the deck above. By 0618, boundary cooling had begun and by 0640, the access doors and vents were all closed. As a result of these actions, the fire eventually burnt itself out.

Following the fire, the master decided to leave the steering gear compartment isolated and he chose not to attempt to run the steering systems. The ship returned to Darwin under its own power with the variable thrust from the twin propellers used to steer.

The investigation found that the fire probably started when rags, which had been soaked in oil that was leaking from a hydraulic unit, were ignited by heat generated by, or a spark emanating from, an electrical solenoid. The investigation also found that the ship's crew had not identified the numerous deficiencies that existed in the ship's emergency equipment, they were not familiar with or appropriately drilled in the use of the ship's emergency equipment and the shipboard response to the emergency situation was neither well managed nor in keeping with the procedures set out in the ship's safety management system (SMS).

¹ All times referred to in this report are local time, Coordinated Universal Time (UTC) + 9 ½ hours.

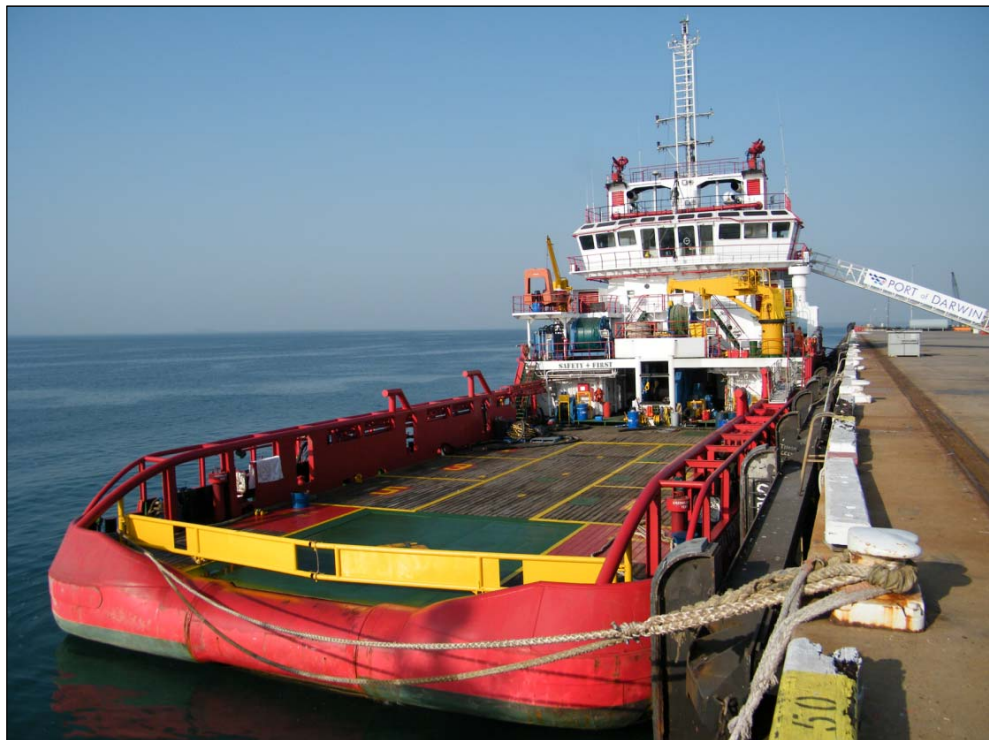
² Aft corner.

The investigation identified two safety issues: while *Petra Frontier* had undergone a series of flag State inspections and class surveys, neither authority was aware that the ship was unseaworthy in relation to critical safety equipment when it departed Singapore; and the ship's SMS contained some contradictory information relating to the scheduling of fire and abandon ship drills.

1.1 *Petra Frontier*

Petra Frontier is an anchor handling tug supply vessel (Figure 1). The ship was built in 2008 by Fujian Crown Ocean Shipbuilding Industry, China. It has an overall length of 60 m, a moulded breadth of 16 m and a deadweight of 1,753 tonnes at a draught of 5.1 m.

Figure 1: *Petra Frontier* berthed in Darwin



Propulsive power is provided by two six-cylinder YANMAR 6EY26 four stroke medium speed diesel engines that together develop 3,840 kW. The main engines each drive a controllable pitch propeller, mounted in a fixed nozzle, which give the ship a service speed of about 13 knots³. The ship is also equipped with bow and stern thrusters.

At the time of the incident, *Petra Frontier* was owned by Mount Bubu, Marshall Islands, and managed by Petra Marine Australia (PMA). It was registered in the Marshall Islands and classed with the American Bureau of Shipping (ABS).

The ship's crew consisted of the master, two mates, three engineers, four integrated ratings (IRs) and a cook, all of whom held the necessary qualifications to allow them to sail on the ship. While at sea, the master and the mates kept a watch keeping routine of 4 hours on and 8 hours off. Three of the IRs acted as bridge lookouts, also keeping a watch keeping routine of 4 hours on and 8 hours off.

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

The engineers did not follow a defined watch keeping routine. Depending on the workload, they sometimes worked 8 hours on and 16 hours off and at other times they worked 4 hours on and 8 hours off. Frequently, they worked for a number of hours beyond the end of their designated watch. One IR worked in the engine room during normal daylight hours.

The master had 35 years of seagoing experience, primarily in the offshore oil and gas industry. He first sailed as master in 1981 and has since had command of a variety of anchor handling, supply and construction vessels. He held a master class one certificate of competency that had been issued in the United Kingdom and a Marshall Islands master's licence. He had worked for PMA in 2008/09 and joined *Petra Frontier* for the first time in Singapore on 31 August 2009, when PMA took over the ship's management.

The chief mate had 56 years of seagoing experience. He started his seagoing career as a deck boy and worked his way up to the rank of master, sailing on various types of trading ships. He retired and in 2002, upgraded his Australian master's certificate of competency in compliance with the STCW⁴ convention in anticipation of returning to the maritime industry. He spent the next 2 years sailing on offshore supply vessels. In 2004, he retired and set up a sail training school. In 2007, he returned to sea and sailed on various offshore exploration and supply vessels. He had worked for PMA once before and joined *Petra Frontier* for the first time on 31 August 2009.

The second mate had 25 years of seagoing experience. He started his seagoing career in Poland and in 1992 migrated to New Zealand, where he gained his second mate's certificate of competency. He sailed on various types of vessels on the New Zealand coast and in 2008, began working in the Australian offshore oil and gas industry. *Petra Frontier* was the second offshore supply vessel he had sailed on. He joined the ship in Darwin, a few days before the incident.

The chief engineer had 42 years of seagoing experience. He started his seagoing career in Pakistan, sailing on oil tankers and container ships. In 1995, he obtained his Australian class one certificate of competency. He continued sailing on trading ships until 2006, when he first sailed on an offshore supply vessel. Since then, he has sailed on various offshore vessels. He also joined *Petra Frontier* for the first time in Singapore on 31 August 2009.

1.1.1 Steering gear compartment

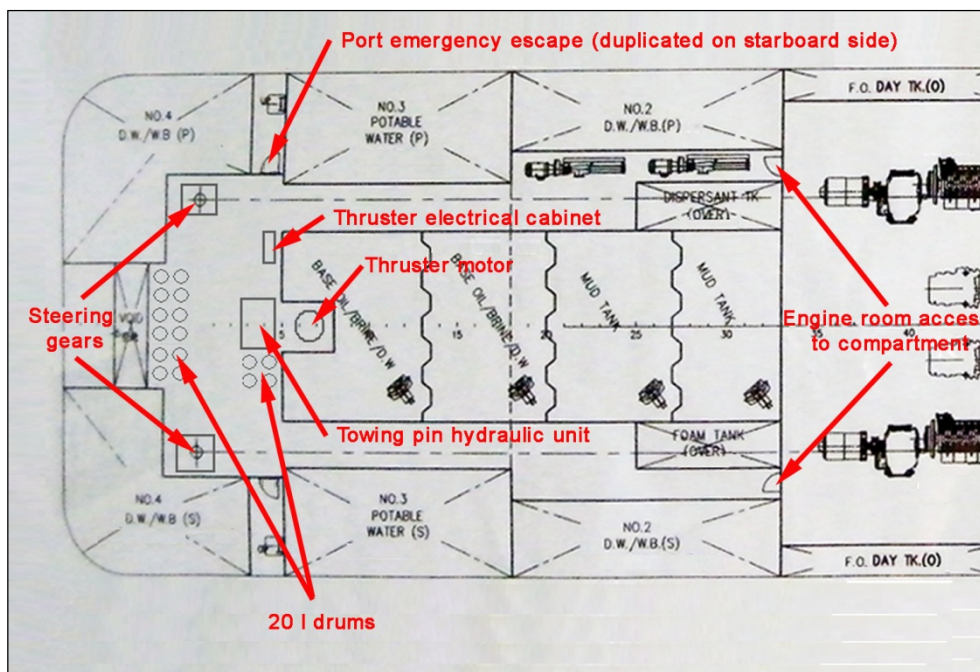
Petra Frontier's steering gear compartment was located aft, below the main deck, on a deck identified on the ship's plans as the 'below tween-deck'. Access to the compartment was via doors located at the forward end of the port and starboard propeller shaft tunnels (Figure 2), providing access between the steering gear compartment and the engine room. The space could also be accessed via emergency escapes located port and starboard aft.

Natural ventilation to the space was provided via vents mounted at the forward end of each of the shaft tunnels. Exhaust fans mounted port and starboard aft drew air from the compartment to the deck above via vents. All four vents could be manually closed from the main deck.

⁴ International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978, as amended in 1995.

The equipment located in the steering gear compartment included the port and starboard electro-hydraulic steering gear units, the towing pin hydraulic unit⁵, the stern thruster electric motor and the electrical supply/control equipment associated with these systems. The space was also used to store 20 litre drums of chemicals and oils which were used on board the ship for various purposes.

Figure 2: Plan of the aft section of the below tween-deck



Fire detection system

The steering gear compartment was monitored by three smoke detectors, mounted port forward, starboard forward and midships aft (above the stern thruster motor), and two manual call points, mounted port forward and starboard forward just inside the entrance doors from the engine room.

When either a fire detector or manual call point was activated, the bridge mounted fire alarm control panel audible alarms operated and a red light, identifying the activated loop, illuminated on the panel. If the bridge mounted control panel alarm was not accepted, the ship's fire alarms automatically activated. An illuminated yellow light adjacent to a fire loop number indicated a system fault on that loop.

1.2 The incident

On 30 August 2009, the master, chief mate, chief engineer, first engineer, an IR and a cook arrived in Singapore to join *Petra Frontier*. They had flown there and were tasked with preparing the ship for its impending voyage to Darwin, Australia.

The next day, the men went on board the ship. It was lying at anchor and the outgoing crew were still on board. The incoming crew did not consider that

⁵ The towing pins are hydraulically raised out of the aft end of the main deck when they are required for guiding tow wires or as a lashing point for bulk cargo discharge hoses.

conditions on board were suitable to allow them to remain on board, so they decided not to stay on board the ship overnight.

Over the following days, the men stayed in a hotel ashore and went on board the ship for about 6 hours each day. During this time, the master and the chief mate negotiated with the crew in an attempt to get everyone to join the ship. However, disagreements over joining the ship and working arrangements created an uneasy feeling between the master/chief mate and the cook/IR.

On 2 September, PMA's general manager and safety and quality manager arrived in Singapore to oversee the handover of the ship.

On 3 September, the remainder of the crew arrived in Singapore. The next day, all the crew agreed to join the ship. Some members of the outgoing crew were still on board and they showed the incoming crew around. However, the handover was not detailed and language differences made communication difficult.

On 5 September, a Lloyds' Register auditor carried out an International Safety Management (ISM) Code audit on board the ship on behalf of the Marshall Islands Registry. Following the audit, the ship was issued with an interim Safety Management Certificate (SMC). Later in the day, an abandon ship drill was carried out and bunkers were taken.

Preparations continued throughout the next day for a departure that was scheduled for the morning of 7 September. The engineers were aware that machinery items including the fuel oil purifier, the lube oil purifier, the sewage plant and the oily water separator were not operating and could not be made operational before the ship departed. However, these faults were not brought to the attention of either the master or the PMA managers.

On 7 September, *Petra Frontier* departed Singapore bound for Darwin. During the voyage, the crew experienced numerous difficulties. The steering system failed to operate reliably, resulting in the crew hand steering the ship from the steering gear compartment for about 36 hours. In addition, the main engines were shutdown on a number of occasions to allow the engineers to repair cooling water leaks and to deal with overheating problems and the main engine fuel filters required changing over and cleaning every few hours because the fuel was 'dirty'.

The disharmony between the master/chief mate and the deck crew increased and, because of a previous confrontation between the chief engineer and the second mate, a general feeling of distrust developed between the mates and engineers.

At 1800⁶ on 15 September, *Petra Frontier* arrived at the Darwin harbour fairway beacon and by 1955, the ship was all fast, port side to the East Arm wharf.

During the ship's stay in Darwin, the crew assisted with the loading of provision stores and cargo. The cargo included potable water and bulk quantities of cement, barite and gel. Fuel oil bunkers were taken on board and the engineers, with the assistance of shore contractors, repaired some of the machinery items that were not operating correctly. An electronics technician also attended to the steering system deficiencies.

⁶ All times referred to in this report are local time, Coordinated Universal Time (UTC) + 9 ½ hours.

While the ship was in Darwin, an ABS surveyor and two technicians attended to the steering system problems while the crew and other contractors attended to general maintenance tasks.

At 1830 on 25 September, *Petra Frontier* departed Darwin, again, bound for *Ocean Shield*.

At 1242 on 26 September, *Petra Frontier* arrived off *Ocean Shield*. Later in the day, an attempt was made to discharge the ship's bulk cargoes. However, the crew experienced some difficulties with the discharge equipment, so the operation was postponed until the next day.

At 1149 on 27 September, discharge of the bulk cement cargo started. Discharge continued until 1310, when it was stopped due to overheating of the cargo transfer compressor. Later in the afternoon, another attempt to discharge the bulk cargoes was made. However, when *Petra Frontier*'s bow thruster was tested before the ship entered the rig's 500 m exclusion zone, three loud banging sounds were heard and the ship listed about 5° to starboard for a few seconds.

The chief mate immediately shut down the bow thruster and aborted going alongside the rig. The crew could not determine what had happened to the bow thruster, but it could not be restarted. *Ocean Shield*'s operators were notified and at 1634, *Petra Frontier*'s master was directed to return to Darwin.

The ship was prepared for the voyage to Darwin and at 1718, departed the area. Shortly afterwards, when the chief engineer exited the steering gear compartment following an inspection of the steering systems, he noticed that the towing pins were still up. He asked one of the IRs to use his hand-held radio to report to the bridge that the pins needed to be lowered. The IR did so and the chief engineer carried on with his machinery inspections.

At about 1800, when the chief engineer handed over the engine room watch to the second engineer, he reported that there were no issues of concern. The second engineer's watch passed quietly and at about 2345, he handed over the watch to the first engineer.

Shortly before midnight, while the master was handing over the bridge watch to the second mate, the fire alarm sounded. The second mate silenced the alarm and then went to inspect the raised deck⁸, the area covered by the activated fire alarm loop. He returned shortly afterwards and reported that he had not found any sign of fire. He reset the alarm but soon afterwards it alarmed again. This time, the master went to investigate. He too found no sign of fire but, now, the fire alarm system would not reset. The two men agreed to leave the raised deck fire alarm loop silenced until the morning. They completed their handover and the master went to bed.

Meanwhile, the first engineer completed an inspection of the running machinery. He checked the bow thruster room and the forward machinery before checking the engine room and the steering compartment. At that time, everything appeared to be operating normally.

The remainder of the second mate's watch was uneventful and at 0400 on 28 September, he handed over to the chief mate.

⁸ The accommodation deck forward and slightly above the main deck. The ship's galley and mess room are located on the raised deck.

At about 0515, the engine room IR woke and went to the mess room. After eating breakfast, he made a cup of coffee and went out to the aft deck. He sat on the grating just outside the accommodation entrance and, as he started to drink his coffee, looked aft. He saw what looked like a white cloud of cement dust above the port quarter⁹. At first, he assumed that the cloud was venting cargo, but when he looked across to the starboard side, he saw a similar cloud. Thinking that something was wrong, he went to the engine room to investigate.

When the IR arrived in the engine room, he made his way to the port side shaft tunnel door, which was closed. He opened the door and stepped inside. He could see smoke at the aft end of the tunnel so he retreated, closed the door and ran to the bridge to raise the alarm.

At about the same time, the chief engineer heard a voice at his cabin door calling, 'I'm dying, I'm dying'. When the chief engineer opened the door, he found the second engineer lying on the alleyway floor, clutching his stomach. The chief engineer helped the second engineer back to his cabin and told him that he would get an ice-pack and notify the master.

Meanwhile, when the engine room IR arrived on the bridge, he reported the fire to the chief mate. The chief mate sent the engine room IR and the bridge lookout to investigate and at 0540, he activated the ship's muster signal.

The two IRs met the chief engineer in the accommodation while they were on the way to the engine room. They told him that there was a fire in the steering gear compartment, so he went with them to investigate.

The three men entered the engine room. They notified the first engineer and then made their way to the port side shaft tunnel door. They opened the door and walked aft, about three quarters of the way down the tunnel, with the chief engineer leading the way. They could not get any further because of the smoke at the aft end of the tunnel, so they exited and closed the door behind them.

The IRs returned to the deck while the chief engineer went to the engine control room to stop the engine room and steering gear compartment ventilation fans. The remaining machinery in the steering compartment was left running. The chief engineer told the first engineer to remain in the control room and to communicate with the bridge while he investigated further.

Meanwhile, the master had arrived on the bridge and the cook and one IR had collected hand-held radios before going to the main deck muster station.

The second mate, the IRs and the cook mustered on the main deck. The second mate took a head-count and then went to the bridge to notify the master that the engineers had not been accounted for. When he arrived there, he was advised that the master had accounted for all the engineers. The second mate then picked up the breathing apparatus (BA) unit that was stored on the bridge and returned to the main deck.

While the second mate was on the bridge, the IRs decided to get the BA units stored in the main deck fire equipment locker. Two of the IR's donned the BA units while the cook checked their air bottle pressures. The cook then remained on the main

⁹ Aft corner.

deck to monitor the actions of the fire party and to report to the bridge, using a hand-held radio.

At 0553, the chief mate stopped both main engines. The ship was now in position 11°47'S 129°05'E (Figure 3).

At about this time, the second engineer called out to the bridge and reported his illness. The master told him to lie down and that he would be attended to as soon as possible.

At 0558, the BA-equipped IRs entered the engine room. The chief engineer and the engine room IR assisted them to the port side shaft tunnel doorway and stayed there while the BA party entered the compartment. They walked aft, as far as the stern thruster electrical cabinet, and then returned to the entrance. They explained to the chief engineer that they thought the smoke was coming from inside the thruster electrical cabinet.

The IRs were given a dry powder fire extinguisher. They went back up the tunnel, opened the stern thruster electrical cabinet door and sprayed the contents of the extinguisher inside. They then returned to the tunnel entrance.

The IRs were given another dry powder fire extinguisher and they returned to the aft end of the shaft tunnel. This time they sprayed the contents of the extinguisher into the thruster electrical cabinet and then moved past it, to starboard. When they were almost adjacent to the towing pin hydraulic unit, they could see hydraulic oil spraying from one of its pipe unions. They also noticed a small pile of smouldering rags that were on top of some 20 litre plastic drums that had been stored hard against the starboard side of the hydraulic unit. One of the IRs pulled the rags to the deck and stomped on them. The two men then returned to the shaft tunnel entrance.

When the IRs explained what they had seen to the chief engineer, he went to the control room and isolated power to the machinery located in the steering gear compartment.

The BA-equipped IRs returned to the tunnel and made it as far as the thruster electrical cabinet. However, on this occasion it was much hotter and the smoke had become darker, so they went no further. They looked to starboard, behind the thruster electrical cabinet and could see a glow in the vicinity of the starboard end of the towing pin hydraulic unit.

At about this time, one of the IRs on deck suggested to the chief mate, via hand-held radio, that they should 'flood the compartment'. The chief mate replied, stating that 'they would not be doing that but that they may use the CO₂'.

The cook overheard the conversation on his radio. When he heard the words 'use the CO₂', he ran to the engine room and told the first engineer that everyone should evacuate the engine room and the steering gear compartment immediately. The IRs in the steering gear compartment were called back, the entrance door was closed and the engine room was evacuated.

At 0610, the chief engineer and the first engineer started the emergency generator. They then activated the engine room emergency stops, shutting down all the running machinery, and tripped the engine room quick closing valves. Once the ship had 'blacked-out', they closed the emergency generator circuit breaker, thus supplying power to the emergency switchboard. The emergency fire pump was then started to supply water to the ship's fire main.

Meanwhile, the master and the chief mate had discussed their available options for fighting the fire. They decided to close the steering gear compartment ventilation dampers and boundary cool the space by spraying water on the aft section of the main deck. They would then wait for the fire to burn itself out.

The chief mate, via hand-held radio, directed the second mate to set up a hose to boundary cool the after part of the main deck. The second mate and the IRs tried connecting a fire hose to hydrants located at the aft port and starboard sides of the accommodation at the main deck level. However, when the hydrants were opened, no water came out. They then connected the hose to a hydrant located further aft and, at 0618, began to cool the aft end of the deck by hosing it with water.

At 0619, the chief mate, via hand-held radio, directed the second mate to concentrate all his efforts on closing the steering gear compartment vents. The second mate tried several times to close the port side emergency hatch but it would not latch. One of the crew got a cut down 205 litre drum, placed it on top of the hatch and put a few large shackles inside it, to weigh it down. However, smoke continued to escape from the hatch. The drum was removed, the hatch opened and oil spill absorbent mats were placed around the rim of the hatch. The hatch was then closed, the drum replaced and filled with water to weigh it down (Figure 4).

Figure 4: Closed hatch with drum on top



The port and starboard forward steering gear compartment vents were shut. A small amount of smoke was still escaping at deck level through a hole in the ventilation trunking, so the IRs blocked the area where the smoke was escaping from with more oil spill mats.

At 0640, the master went to the aft deck. When he arrived, he noticed that the port and starboard aft vents were still open. He shut one vent and instructed one of the IRs to shut the other. He then directed the second mate to go to the bridge to send a distress message.

At 0654, a fire hose was set up in the engine room in case it was necessary to boundary cool the aft engine room bulkhead.

At 0700, the chief mate and the second mate sent an automated Inmarsat-C 'fire' distress message, followed by a similar automated 'medical' distress message. Soon afterwards, receipt of the messages was confirmed by the Burum, Netherlands, Land Earth Station (LES).

The distress message was forwarded to the Australian Rescue Coordination Centre (RCC) who made efforts to contact the ship. At 0732, an Australian search and rescue aircraft, which was in *Petra Frontier*'s vicinity, made contact with the ship on VHF channel 16. The aircraft remained in contact with the ship, relaying messages to and from the RCC.

At 0812, the ship's normal electrical power was restored and the emergency generator was shut down.

Throughout the morning, the master had been dividing his attention between the fire response and the ill second engineer. At 0814, when things started to quieten down, he made a VHF call, requesting medical advice. He advised the doctor that he suspected that the second engineer was suffering from appendicitis and he was given some treatment advice. He also made a number of calls requesting a medivac for the ill second engineer.

Boundary cooling of the deck continued and the crew attempted to change over the BA air bottles and refill the used ones. However, there were two types of air bottles and they were not all interchangeable. In addition, the electrical plug fitted to the refilling compressor was not compatible with any of the ship's electrical outlets.

A fire party was readied for the arrival of a medivac helicopter and boundary cooling of the deck was stopped to ensure that it was as dry as possible when the helicopter arrived.

The medivac helicopter arrived at the ship's position and at 1121 a paramedic was lowered onto the ship's deck. The paramedic assessed the second engineer's condition and then assisted him to the deck so that he could be winched up to the helicopter. At 1127, the two men were winched off the ship's deck. The helicopter then departed the area.

The second engineer was flown to the Darwin Hospital where he was diagnosed with gastroenteritis. Later that evening, when his symptoms eased, he was discharged from the hospital with a medical certificate for 2 days off work.

At about 1200, the master gathered all the crew on the bridge and they discussed the situation. There was no longer any smoke escaping from the steering compartment and the master considered that the fire had been extinguished. He also informed the crew that there were no tow vessels available at this time so they would sail the ship to Darwin under its own power, using variable thrust from the twin propellers to steer. Preparations for the voyage were made and by 1230, the main engines had been started and placed in bridge control. The master then set a course for Darwin.

Petra Frontier arrived off Darwin shortly after midnight and by 0020 on 29 September, the ship's anchor had been let go in the anchorage. The ship remained at anchor for the remainder of the night.

At 0825, a harbour pilot boarded *Petra Frontier* and, with the assistance of a tug, he navigated the ship into the port. By 1140, it was all fast alongside Fort Hill wharf.

While *Petra Frontier* was in Darwin, an assessment of the damage caused by the fire was carried out while a manufacturer's technician investigated the bow thruster failure. It was determined that the bow thruster could only be repaired in a dry dock. As a result, temporary repairs to the systems damaged by the fire were carried out so that the ship could sail to Singapore.

On 13 October, *Petra Frontier* departed Darwin bound for Singapore.

2.1 Evidence

On 29 September 2009, investigators from the Australian Transport Safety Bureau (ATSB) attended *Petra Frontier* while the ship was berthed in Darwin. The master and directly involved crew members were interviewed and they provided their accounts of the incident. Photographs of the ship and copies of relevant documents were obtained; including log books, charts, reports, manuals, procedures and statutory certificates.

On 1 October, two members of the Northern Territory Fire and Rescue Services fire investigation unit attended the ship to inspect the fire scene and to assist the ATSB investigators with an analysis of the fire.

During the course of the investigation, further information was provided by Petra Marine Australia (PMA).

2.2 The fire

At about 1720 on 27 September, while *Petra Frontier* was en route from *Ocean Shield* to Darwin, the ship's towing pin hydraulic unit was started by the bridge watch keeper so that he could lower the towing pins. It was normal practice on the ship for the towing pin hydraulic unit to be run only while the pins were being raised or lowered. However, on this occasion, the hydraulic unit was not shutdown after the pins were lowered.

None of the bridge watch keepers on duty later that night noticed that the running lights on the towing pin hydraulic unit starter panel were illuminated. Furthermore, none of the watch keeping engineer's noticed that the hydraulic unit was running, or if oil was leaking from it, when they inspected the steering gear compartment during their watches that night.

At about 0600 on 28 September, when the breathing apparatus (BA) equipped IRs entered the steering gear compartment in an attempt to extinguish the fire, they saw oil spraying from a hydraulic pipe union on the towing pin hydraulic unit. The pipe union was later identified as the one connecting the hydraulic pump discharge pipe to the control valve block (Figure 5) and an inspection carried out by the ATSB investigators found that the union was little more than finger tight.

The leak probably started as a drip and then grew into a spray as the pipe union loosened. The first engineer did not notice anything unusual when he inspected the steering gear compartment at about midnight. Therefore, it is likely that the oil did not start spraying until sometime after that.

At the time of the incident, the ship was less than a year old and there were no records of any maintenance being carried out on the hydraulic unit pipe work. Therefore, the hydraulic unit pipe work was probably in its original condition. Since the unit was normally run only for short periods of time, it is possible that it had never before run for such a long period of time. As a result, it is likely that the pipe union, which was probably not sufficiently tight in the first place, had not had a prior opportunity to work loose.

The un-cooled hydraulic unit had been running for more than 10 hours. As a result, the pump and the system oil were probably hot. It is possible that the temperature of the oil was as high as 70°C.

The hot leaking oil sprayed around the area, saturating the starboard side of the hydraulic unit, the electrical fittings located there and some used cotton rags (rags) that had been left on top of the drums near the end of the hydraulic unit tank. The drums were about the same height as the hydraulic oil tank and the rags were near the tank's starboard end and perhaps even on top of it.

The exact source of ignition could not be identified. However, the only likely ignition source was the connecting plug of an electrical solenoid located at the starboard side of the hydraulic unit (Figures 5 and 6). The hot oil spray probably penetrated the fitting, causing it to short circuit. The short circuit either created enough heat, or a spark, which ignited the oil soaked rags. The rags probably began to smoulder, producing the white smoke that was first seen by the ship's crew.

When the BA-equipped IRs saw the smouldering rags, they put them on the deck and stomped on them. However, the evidence indicates that not all of the rags were removed and that some rags had fallen between the drums and the hydraulic unit tank (Figure 7). The supply of air to these rags probably increased when the rags around them were removed and the smouldering developed into a flame. The fire then grew in size, consuming the available hot hydraulic oil. It was probably at this time that the crew noted the smoke change colour from white to black and the heat in the compartment start to increase.

Figure 5: Towing pin hydraulic pump discharge pipe

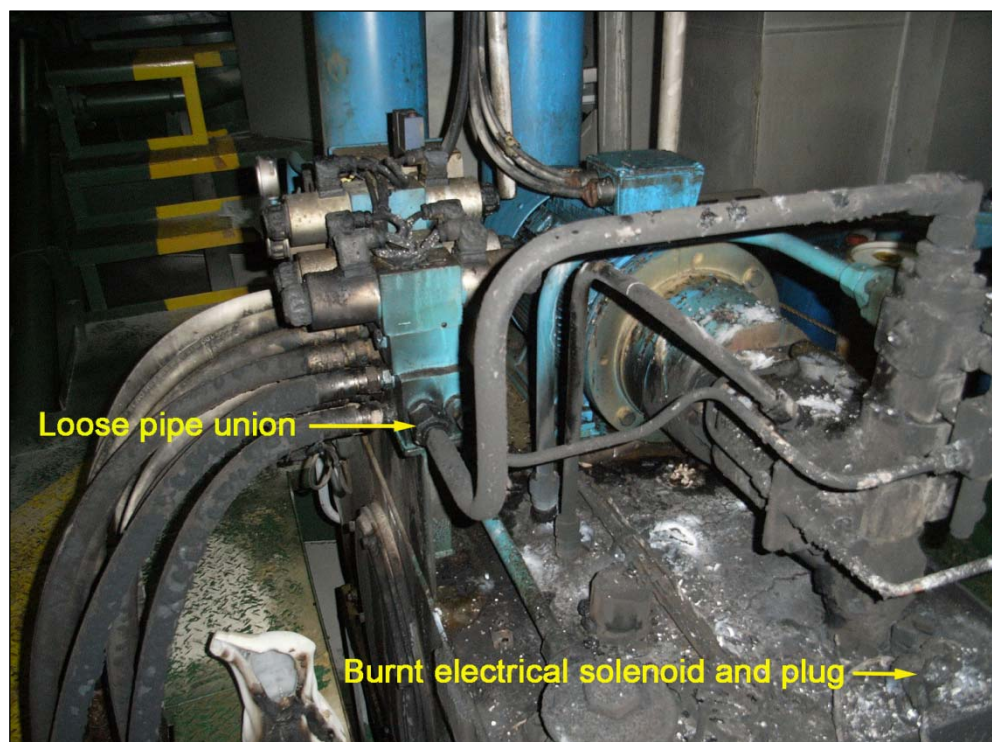
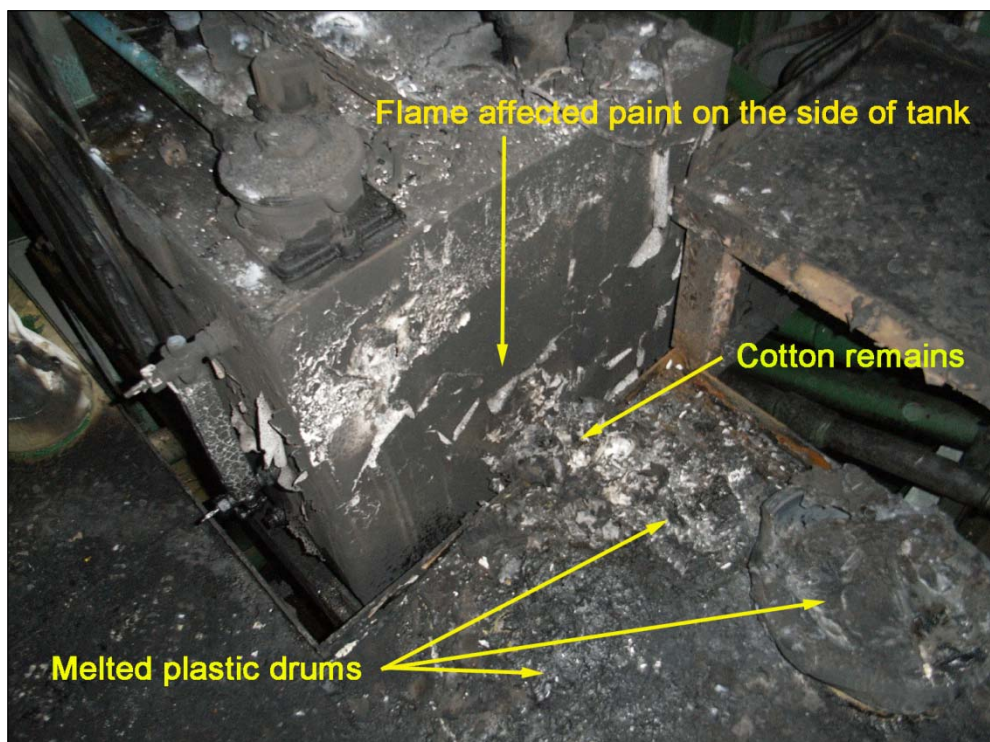


Figure 6: Remains of the electrical solenoid and connecting plug



Figure 7: Burnt remains of rags at the side of the hydraulic oil tank



When the chief engineer shut down all the steering gear compartment machinery, the flow of oil stopped; and when the ventilation dampers were closed, the supply of air was restricted. While there was heat related damage to lighting and electrical equipment located as far as 3 m from the towing pin hydraulic unit, the flame

damage was localised and confined to an area on and above the hydraulic unit (Figure 8). Therefore, it is likely that the fire continued to burn for a short period of time, on and around the starboard side of the hydraulic unit, until it burnt itself out.

Figure 8: Spread of fire related damage

2.3 Fire alarms

In the early hours of 28 September, following two ‘false alarms’, *Petra Frontier*’s master and the second mate decided to leave the raised deck fire detection loop (loop 5) silenced until the morning. This action was probably reasonable, they could not reset the loop, they had confirmed that there was no sign of fire on the raised deck and, since the area was close to the bridge, it could be regularly checked by the lookout.

However, later that morning, a fire started in the ship’s steering gear compartment and the fire detection system did not alert the crew to this fact.

Following the fire, the bridge mounted fire detection panel was inspected. The panel was indicating a fault on the raised deck loop, consistent with the explanation provided by the master and second mate, and a fire on the steering compartment loop (loop 7).

The steering compartment fire detectors were also inspected. The detector mounted directly above the towing pin hydraulic unit had been damaged by the fire and, as a result, did not provide any evidence of activation. However, an inspection of the detector mounted in the forward end of the starboard shaft tunnel indicated that it had activated.

The operation of the fire detection system was also tested. When individual detectors were activated, the alarm panel indicated a fire on that loop and the fire alarms sounded.

The crew reported that the fire alarm system did not alert them to the fire either before or after it was discovered. However, the evidence indicates that the system did activate. Since no one heard an alarm before the muster signal was operated, it is likely the fire alarm was activated later, during the crew’s emergency response. While no one on the bridge that morning remembers silencing the fire alarms, it is possible that the master, the chief mate or the second mate silenced the alarm when it sounded; and that they were busy concentrating on their response to the fire and hence did not register that they did so.

Why the fire alarm system did not alert the crew to the fire could not be confirmed. However, it is possible that, in the early stages of the fire’s development, the smouldering rags did not produce a large amount of smoke. Furthermore, the air flow in the steering compartment with the exhaust fans running was from forward to aft and it may have been drawing the smoke away from the detectors. It is possible that when the exhaust fans were stopped by the chief engineer during the emergency response, that the detectors finally activated.

Following the fire, PMA engaged the services of a specialist fire equipment contractor. The contractor replaced the damaged detector, checked the other system components and tested the operation of each of the steering compartment fire

detectors. These tests confirmed that the fire detection system was functioning correctly.

2.4 Emergency response

The response to the fire by the crew members who had mustered on the main deck was prompt and well intentioned. They followed practices that they had learnt through their previous training and experience. However, their response was not well managed and an early attempt to restrict the supply of air and fuel in the steering compartment was not made.

2.4.1 Control and coordination

When the IR discovered the fire, he ran to the bridge to alert the bridge watch keeper. He could have activated a fire alarm call point, but he chose not to because he was aware that there had been some ‘false alarms’ and he wanted to avoid any confusion.

At 0540 on 28 September, when the chief mate activated the ship’s muster signal, he was alone on the bridge and the chief engineer, the lookout and the engine room IR were on their way to the engine room to investigate the fire.

Following the muster signal, the master came to the bridge, his designated muster station, and the remaining crew members mustered at their muster stations on the main deck and in the engine room. However, the chief mate, the designated ‘on scene commander’ on the muster list, remained on the bridge. As a result, there was no ‘on scene commander’ and the initial stages of the response to the fire were not effectively controlled or coordinated.

Since the mustered crew on the main deck were without their designated leader, the second mate accounted for them and reported to the master. He then went about preparing the BA equipment, his muster list assigned task.

Other crew members assisted the second mate and prepared for an attempt to enter the steering compartment with the aim of extinguishing the fire. Two crew members put on BA units and the cook checked the pressure in the BA air bottles.

At 0558, the BA-equipped crew members entered the port side shaft tunnel in an attempt to investigate, and possibly extinguish, the fire. This action was reported to the bridge. However, the decision to enter was made by the crew members on the main deck without consultation with, or coordination by, the master and/or the chief mate.

The chief engineer had stopped the steering compartment ventilation fans before the fire party entered the shaft tunnel. However, the ventilation dampers had not been closed and the electrical power supply to the various items of machinery located in the space had not been isolated. Therefore, the fire was still being supplied with ample quantities of both air and fuel.

After the fire party’s second attempt to extinguish the fire, they reported to the chief engineer that oil was spraying from the towing pin hydraulic unit. The chief engineer then isolated the power to the steering compartment machinery. However, the ventilation dampers were still not closed.

At about 0605, the cook overheard a discussion on the radio in which there was a mention of 'use the CO₂'. There had been no intention on anyone's part to activate the ship's fixed fire extinguishing system; in fact the system did not discharge into the steering compartment/shaft tunnel area. However, it is understandable that the cook, on hearing 'use the CO₂', might have concluded that the system was going to be used. Hence, his actions in warning his colleagues in the engine room and the shaft tunnel, in the absence of any informed leadership, were fair and reasonable.

The two men in the shaft tunnel, and those that were in the engine room assisting them, retreated to the main deck. Once there, the chief engineer and the first engineer started the emergency generator, stopped all the running engine room machinery and operated the quick closing valves. The chief engineer then reported to the master that the engine room was ready for the release of CO₂. It was only then that the master told the chief engineer that there was no intention to release the CO₂.

A simple misunderstanding by a well intentioned crew member had led to the retreat of the fire attack party and the blacking out of the ship. Had the chief mate been on the main deck, acting as an effective on scene commander, it is likely that this misunderstanding would not have occurred.

Shortly after 0610, about 30 minutes after the muster signal had been sounded, the chief mate instructed the second mate, via hand-held radio, to start cooling the main deck with sea water. Crew members started connecting fire hoses to what they thought were fire hydrants located on the main deck just aft of the accommodation. However, when the hydrants were opened, no water flowed. The crew discovered that while these hydrants were painted red, they were not connected to the fire main. The crew then located a nearby fire hydrant, connected the fire hoses and at 0618, began cooling the main deck with seawater.

At 0619, the chief mate directed the second mate, once again via hand-held radio because he was still on the bridge, to concentrate his efforts on closing the steering compartment ventilation dampers. The second mate and the crew then concentrated on this task while they continued hosing the main deck.

At 0640, the master left the chief mate on the bridge and went to the main deck. From this point on, the crew's response became more organised. The master could now see first-hand what needed to be done and he could effectively direct the crew. In turn, the crew responded favourably to the master's control and coordination. However, this organised approach to the fire fighting response did not commence until an hour after the muster signal had been activated.

The fire was not large and it could have been extinguished before any substantial damage occurred. All that was required was a prompt, well managed, coordinated response following a series of proven and trained for steps; stop the fans and close the ventilation dampers; isolate power to all equipment in the space; then enter the space and extinguish the fire.

2.4.2 Breathing apparatus (BA) equipment

After mustering, the crew went about preparing the BA equipment. They located the equipment and brought it to the main deck. However, they could not find a BA board¹⁰, so the cook recorded the air bottle pressures in a note book.

The BA equipment was operable and gave no problems while it was being used. However, later, when the crew were preparing the equipment for further use, they discovered that the threads on some of the spare air bottles were different to those on the BA equipment that had been used in the response. As a result, these spare (full) air bottles could not be fitted to the BA units that had been used in the response.

The crew also discovered that the air bottle re-filling compressor had an electrical plug that was not compatible with any of the ship's electrical outlets. Therefore, it could not be used to refill the used air bottles. While it was not a class requirement for *Petra Frontier* to carry a re-filling compressor, the ship's operators had decided to carry one on board and it should have been operable.

The crew had no prior knowledge of these deficiencies and as a result, they were caught off guard. Had the circumstances been different, running out of usable air bottles may have had severe consequences.

2.4.3 Emergency messages

The master initially decided that it was of primary importance that he concentrate on the fire fighting response. As a result, it was not until shortly after 0640 that he directed the second mate to go to the bridge and send a distress messages. However, with both the chief mate and the master on the bridge, it should have been possible for both tasks to have been completed at the same time.

At 0700, the second mate and the chief mate sent automated Inmarsat-C 'fire' and 'medical' distress messages. Receipt of these messages was confirmed by the Burum, Netherlands, land earth station (LES).

An automated process at the Burum LES would have forwarded these messages to the Netherlands Rescue Coordination Centre (RCC). There, an operator would have checked them and, because the ship was in Australia's search and rescue region, forwarded them to RCC Australia for action. While the desired outcome of notifying RCC Australia was achieved, the process was not as seamless as it could have been.

With reference to routing of distress calls, the Australian Global Maritime Distress and Safety System (GMDSS) Handbook states:

Some ship earth station equipment will send a distress alert to the "preferred LES" (a stored entry in the distress message generator) or, if this entry has not been made, to the LES most recently in communication with the ship earth station.

Other types of ship earth station require the operator to select a LES through which to send a distress alert or call. This should be the nearest LES to the distressed vessel. If a LES is not specified either by the equipment or the operator, the distress

¹⁰ A small chalkboard or whiteboard that is used to log BA air bottle pressures and the times that various crew members enter and/or exit a space during an emergency response.

alert will be routed via the network co-ordination station (NCS) and may result in an unnecessary delay.

As stated in the GMDSS Handbook, it is good practice for a ship's Inmarsat-C system to be set up so that automated distress messages are forwarded to the LES of the appropriate local search and rescue authority. In Australia's search and rescue region, the appropriate LES station is located in Perth, Western Australia.

Had *Petra Frontier*'s Inmarsat-C system been set up so that the Perth LES was the preferred LES, any distress message would have been automatically forwarded to RCC Australia, thus removing the delay in delivery and possible error in the transmission of the message.

2.5 Emergency preparedness

When a crew joins a ship for the first time, their primary responsibility is to ensure that they gain a working knowledge and understanding of its equipment and systems. From a commercial point of view, this means quickly learning how to operate the ship so that it can start providing a financial return to its owners and operators.

However, more importantly, the crew are required to gain a thorough understanding of the ship's emergency equipment. They should become familiar with the location of the equipment, practice using it and practice implementing the company's emergency response procedures. This process not only exercises the crew in how to work as a team, it identifies equipment and organisational deficiencies that require rectifying. Effectively carrying out these tasks should ensure that both the crew and the equipment are appropriately prepared to respond to an emergency situation.

On 28 September 2009, the actions of *Petra Frontier*'s crew demonstrated that they were not adequately prepared for a response to an emergency situation such as the one they found themselves in. It was not until the crew responded to the fire that they identified that:

- not all of the BA air bottles were interchangeable;
- the electrical plug on the BA air bottle re-filling compressor was not compatible with the ship's electrical outlets;
- there was no BA board;
- the wash-down water outlets on the main deck that had been painted red were not fed from the fire main;
- the port side steering compartment emergency hatch would not close and latch correctly; and
- the chief mate would not take charge on the deck and manage the response.

2.5.1 Crew induction

Petra Frontier's safety management system (SMS) contained a procedure that outlined how, when first joining the ship, each crew member should be familiarised with the ship and its equipment, their responsibilities and the company's management systems. This procedure was aimed at meeting the ISM Code requirement that states:

The company should establish procedures to ensure that new personnel and personnel transferred to new assignments related to safety and protection of the environment are given proper familiarization with their duties. Instructions which are essential to be provided prior to sailing should be identified, documented and given¹¹.

It was an SMS requirement that the familiarisation was undertaken using standard checklists that, when completed, were to be signed by the participating crew member and then kept on file. Amongst other things, the checklists included the location of fire alarm activation points, fire fighting equipment and life saving equipment. On board *Petra Frontier*, this familiarisation process was carried out by the chief mate.

When the ATSB investigators attended *Petra Frontier* following the fire, they found a list of signatures confirming that, on 4 September, all the crew had been familiarised as per the procedure. The file included three induction checklists dated 9 September, but it did not include a familiarisation checklist for each of the crew members on board the ship at that time.

While *Petra Frontier* was in Singapore, PMA's safety and quality manager provided the crew with a presentation outlining the company's SMS. However, when interviewed, a number of crew members stated that they had not received any practical familiarisation from the ship's officers. They had simply been asked to sign the forms before the ISM Code interim audit was carried out in Singapore on 5 September. The crew members indicated that they expected that practical familiarisation and training would be carried out when things weren't quite so busy, probably after the ship had sailed from Singapore on its voyage to Darwin.

¹¹ International Safety Management (ISM) Code 2002, section 6.3

While an interim ISM Code audit was completed before the ship sailed from Singapore, it is probably unrealistic to expect that the auditor would discover that the ship's familiarisation procedure had not been effectively implemented. The aim of the interim audit is to determine that; the ship's managing company holds a document of compliance (DOC) for the particular ship type; there is an approved SMS on board the ship; the crew have an understanding of the SMS; and there is an intention on behalf of the company and the crew to implement the SMS. Auditing the effectiveness of the SMS and its implementation on board the ship is not feasible as there is little history on which to base an appraisal. Therefore, these tasks are left for later audits.

The master and the chief mate may have considered that it was a commercial necessity for the ship to sail from Singapore as soon as possible and that it was acceptable to complete the familiarisation paperwork before sailing and complete the tasks afterwards. However, they did not comply with the SMS requirements and, more importantly, did not ensure that the crew was familiar with the ship's equipment, the on board management systems or their individual responsibilities.

2.5.2 Drills and training

The Marshall Islands marine regulation 7.41.6 outlines the authority's requirements in relation to drills and training:

The Master of each vessel shall cause the crew to be exercised at fire and/or abandon ship drills or safety training at least once in every week. In addition, the requirements of SOLAS Ch. III – 19.3 are to be satisfied every month, or within 24 hours of the ship leaving port if more than 25% of the crew have not participated in fire and abandon ship drills collectively satisfying the requirements of SOLAS Ch. III – 19.3 on board that particular ship the previous month....

With reference to drills and training, SOLAS Chapter III Regulation 19.3.2 states:

Every crew member shall participate in at least one abandon ship drill and one fire drill every month. The drills of the crew shall take place within 24 h of the ship leaving a port if more than 25% of the crew have not participated in abandon ship and fire drills on board that particular ship in the previous month. When a ship enters service for the first time, after modification of a major character or when a new crew is engaged, these drills shall be held before sailing. The Administration may accept other arrangements that are at least equivalent for those classes of ships for which this is impracticable.

On 5 September 2009, before *Petra Frontier* departed Singapore, a muster drill was carried out on board the ship. This was the only drill completed before the ship departed Singapore and was recorded in the official log book as an abandon ship drill. The crew were required to respond to an alarm by mustering at their designated muster stations. However, the drill did not involve the breaking out or exercising of life saving equipment and hence did not meet the SOLAS definition of an abandon ship drill¹².

Therefore, the statutory requirement that abandon ship and fire drills be completed before the ship sailed from Singapore had not been complied with.

¹² SOLAS Chapter III Regulations 19.3.3 and 19.3.4

SMS procedures

Petra Frontier's 'Standard Operating Manual' included a procedure that outlined how fire and emergency drills would be carried out in accordance with SOLAS requirements. This procedure included a statement that mirrored the Marshall Islands requirements and referred to a standard form for the recording of completed drills. This drill record form reinforced the statutory requirement for monthly abandon ship and fire drills by outlining how often abandon ship and fire drills should be completed.

However, this information was contradicted by the ship's 'Ship Management Systems' document that contained a drill schedule. According to this drill schedule, a fire and emergency drill was due in the week beginning Monday 17 August 2009, before the crew joined the ship in Singapore. The next fire and emergency drill was due 6 weeks later, in the week beginning Monday 28 September.

In response, PMA stated that:

The drill schedule referred to in the ATSB Report is a schedule from the Ship Management System, which does not mention abandon ship drills, and should be read in conjunction with the PMA Standard Operating Manual. In this instance because the vessel had a major crew change in Singapore the Standard Operating Manual requirement of additional drills should have been complied with.

However, the master had planned to carry out the crew's first fire drill in the week beginning Monday 28 September, as required by the drill schedule contained in the Ship Management Systems document. Unfortunately, the fire occurred on board the ship on the morning of 28 September, before this planned drill.

Hence, when the fire occurred that morning, the crew had not practiced their response to a similar emergency situation. As a result, they were not familiar with the location of the emergency equipment and they had not assured themselves that all the equipment was in place and operable. Furthermore, they were not familiar with their individual responsibilities or the emergency response procedures.

When a crew is new to a ship, or when more than 25 % of the crew has changed, relying on the minimum statutory requirements and a long term drill schedule is not enough. In the short term, the crew needs to be sufficiently drilled and trained to ensure that they know where the ship's emergency equipment is located and have practiced using it. They also need to assure themselves that the equipment operates correctly and that they have a thorough understanding of their individual roles and how their actions affect the team as a whole.

2.5.3 Inter-departmental relationships

Petra Frontier's master and crew encountered a number of obstacles that may have affected their joint intention of working together to ensure that they were appropriately prepared to respond to an emergency situation.

The refusal by two members of the crew to initially join the ship in Singapore soured relationships between the senior deck officers (master and chief mate) and those crew members. When the remainder of the crew joined the ship they sided with their respective colleagues and a divide was created between the senior deck officers and the deck crew.

Relationships were further tested by a feud between the chief engineer and the second mate that had been carried over from their previous experiences sailing together. These problems peaked during the voyage from Singapore to Darwin when there were problems with the ship's steering system. The second mate investigated the problems and made adjustments to the steering hydraulic system without involving or advising the engineers. In response, the chief engineer refused to offer any assistance because he had not been consulted in the first place.

While the second mate went on leave and handed over his duties to a new second mate a few days before the fire, on board relationships remained strained. When the ATSB investigators attended *Petra Frontier* in Darwin, on board relationships had further deteriorated. The senior deck officers did not trust the deck crew or the engineers and the deck crew and the engineers did not trust the senior deck officers.

On 28 September, during the initial and extremely important stages of the emergency response, the master and the chief mate remained on the bridge and discussed how they should best respond to the fire, without involving or effectively directing the crew. At the same time, the crew assembled on the main deck and decided to enter the space and extinguish the fire without waiting for direction from the master or chief mate. The actions of the two groups were independent of each other. This suggests that the pre-existing inter-departmental issues were having a disruptive effect on the crew's ability to work together as a cohesive team.

Joining a new ship and preparing it for commercial operations involves overcoming unforeseen obstacles. It is always a time of high workload and relationships are often tested. However, these difficulties need to be managed and each crew member must play their part in the team to ensure that the desired outcomes are achieved.

2.6 Seaworthiness

According to Miller's Dictionary of Nautical Words and Terms, seaworthiness is defined as:

In a limited sense, is the vessel's fitness to withstand the action of the sea, wind and weather. In a broader, and legal, sense, it requires that the vessel must be handled and navigated competently, fully manned, adequately stored, and in all respects fit to carry the cargo loaded.

While the seaworthiness of a ship should be assured through a series of regular surveys and inspections carried out by its flag State and classification society (class), it is ultimately the master's responsibility to decide when a ship is seaworthy and hence in a fit state to go to sea. However, the master should be appropriately supported by the ship's crew and its managers.

Petra Frontier was less than a year old and it had undergone an initial Marshall Islands flag State inspection on 4 May 2009. The attending surveyor noted that all was in good order and that no deficiencies were observed. Furthermore, the American Bureau of Shipping (ABS) carried out a class survey on board the ship between 7 and 12 August 2009. This survey did not note any deficiencies.

On 30 August, *Petra Frontier*'s master, chief mate, chief engineer, first engineer, an integrated rating (IR) and a cook arrived in Singapore. The ship was scheduled to depart Singapore 8 days later.

On 2 September, PMA's general manager and safety and quality manager arrived in Singapore to oversee the handover of the ship. The managers concentrated their efforts on the logistics of getting the ship ready to sail from Singapore. They considered that if they carried out tasks like organising stores, bunkers, surveys and pilots, the master and the crew would be able to concentrate on preparing the ship. However, the managers did not ask the master to confirm that the ship was, in his opinion, seaworthy before they allowed it to sail from Singapore.

On 3 September, the remainder of the crew arrived in Singapore and on 7 September, the ship departed Singapore bound for Darwin. The ship's engineers were aware that some machinery items were not operating, including the fuel oil purifier, the lube oil purifier, the sewage plant and the oily water separator. However, these issues were not brought to the attention of the master or the PMA managers.

In submission, PMA stated that they had contacted class and that they had no reason to suspect that *Petra Frontier* was not seaworthy when they took over management of the ship. PMA added that:

Discussion with Petra Technical Dept did not inform PMA of any machinery malfunction. Post discussions with them informed us that they also were not aware of any machinery malfunctions at that time.

Discussion with previous crew and examination of their maintenance records did not report any malfunctioning machinery.

During the voyage to Darwin, the crew experienced a number of mechanical difficulties with the ship's systems. The steering system failed to operate reliably, resulting in the crew hand steering the ship for about 36 hours, the main engines were shutdown on a number of occasions to allow the engineers to repair cooling water leaks and to deal with overheating problems and the main engine fuel filters required changing over and cleaning every few hours because the fuel was 'dirty'.

On 16 September, after *Petra Frontier* had berthed in Darwin, an Australian Maritime Safety Authority (AMSA) surveyor carried out a Port State Control (PSC) inspection on board the ship. The PSC inspection report listed 19 deficiencies, including seized engine room vents, defective fixed carbon dioxide (CO₂) fire extinguishing system, defective oil tank quick closing valves, seized paint locker CO₂ system isolation valve and blocked paint locker water spray nozzles. As a result of the inspection, the surveyor detained the ship, noting that it was 'unseaworthy'.

On 28 September, the day of the fire, the crew discovered that there was no BA board, not all of the BA air bottles were interchangeable, the electrical plug fitted to the air bottle refilling compressor was not compatible with any of the ship's electrical power outlets and the port side steering compartment escape hatch would not close and latch correctly.

None of these deficiencies are likely to have developed in a short period of time. Therefore, it is likely that most of the defects found by the AMSA surveyor in Darwin, and those that were discovered by the crew during their response to the fire, existed when *Petra Frontier* departed Singapore.

In response, ABS stated that:

The fixed CO₂ fire suppression system, self-contained breathing apparatus, emergency escape breathing apparatus and breathing air compressor were all serviced by a reputable firm in Singapore on 19 August 2009, a week after ABS's last survey. ABS was not asked to attend and did not attend. Any defects in the CO₂ system should have been addressed by the servicing. Unfortunately, we fear the servicing may have created some of the conditions....

Similarly, ABS has learnt the vessel was serviced in ST Marine Shipyard in Singapore between 21 and 24 August 2009. Once again, the work was performed after ABS's annual survey and ABS was not called to attend at the shipyard. The shipyard's repair assignments included "To crop remove and relocate the fire line of aft main deck port side..." which included "to blank off existing pipe during hot work." We suspect that the confusion over which hydrants were connected to the fire main was caused by relocation of the fire line....

While *Petra Frontier*'s operators may not have advised ABS of all the issues on board the ship, it was less than a year old and it had undergone an initial flag State inspection and routine class surveys. Furthermore, PMA sent two senior managers to oversee the ship handover process and tasked an appropriately qualified and experienced master and crew to join the ship in Singapore. However, the combined efforts of the master, the crew, the ship's managers, the class society and the flag State were not sufficient to ensure that the ship was seaworthy when it departed Singapore.

2.7 Housekeeping

Good housekeeping practices on board a ship should ensure that occupational accidents such as slips, trips and falls are minimised. These processes should also be aimed at reducing the risks associated with serious events such as fire.

Good housekeeping practices should ensure that loose drums of chemicals and oils are stored in a space that is protected by a fixed fire extinguishing system. The space should include stowage that enables the drums to be held securely, so they do not move in a seaway. The stowage should also be laid out so that chemicals or oils that may be reactive with each other can be stored separately.

However, on board *Petra Frontier*, 20 litre drums of chemicals and oils were stored on the deck in the steering compartment and, while the crew had lashed the drums in place, they were not stored securely (Figure 8). Furthermore, the space was not protected by a fixed fire extinguishing system.

Not only were the chemicals stored in *Petra Frontier*'s steering compartment, but used oily rags had been placed on top of them. Used oily rags are a safety hazard and have been linked to the source of many machinery space fires, including this one. Therefore, they should never be left lying around machinery spaces. Used rags should always be placed in appropriate garbage containers that are regularly emptied, thus eliminating a possible source of fuel from machinery spaces.

3.1 Context

Shortly before 0540 on 28 September 2009, a fire started in the steering gear compartment of the Marshall Islands registered anchor handling tug supply vessel *Petra Frontier* while it was en route from the Timor Sea to Darwin, Northern Territory.

The ship's crew responded to the fire but they were unable to extinguish it using portable fire extinguishers. The steering gear compartment access doors and supply/exhaust vents were closed; the electrical power supply to the machinery located in the compartment was cut off; and the deck above was boundary cooled. As a result, the fire eventually burnt itself out.

From the evidence available, the following findings are made with respect to the fire on board *Petra Frontier* on 28 September 2009. They should not be read as apportioning blame or liability to any particular organisation or individual.

3.2 Contributing safety factors

- At about 1720 on 27 September 2009, *Petra Frontier*'s towing pin hydraulic unit was started and the towing pins were lowered. However, when the pins were lowered, the hydraulic unit was not shut down.
- During the night, a pipe union on the hydraulic unit worked loose. Oil began leaking from the union and, over time, the leak grew into a spray. The spray of oil saturated the starboard end of the hydraulic unit, the electrical fittings located there and some rags that had been left nearby.
- Two engineers inspected the machinery in the steering gear compartment that night. However, neither of them noticed that the towing pin hydraulic unit was running or if there was oil leaking from one of its pipe unions.
- The leaking oil probably penetrated the connecting plug of an electrical solenoid located at the starboard end of the hydraulic unit, causing it to short circuit. The short circuit either created enough heat, or a spark, that was sufficient to ignite the oil soaked rags.
- The fire grew in size because there was no attempt in the early stages after it had been detected to restrict the supply of available fuel and air in the steering gear compartment.
- Following the fire alarm, the crew mustered at their designated muster stations. However, no one took charge on the deck because the chief mate, the muster list's designated 'on scene commander', remained on the bridge. As a result, the crew's response to the fire was not effectively controlled or co-ordinated.
- *Petra Frontier*'s crew had not been appropriately inducted, drilled or trained in the use of the ship's emergency equipment and they were not familiar with the equipment or their roles and responsibilities in an emergency response.

- *Petra Frontier's* safety management system contained procedures outlining how fire and abandon ship drills should be carried out in accordance with SOLAS and Marshall Islands requirements. However, it also contained a drill schedule that provided some contradictory information. [*Minor Safety Issue*]
- *Petra Frontier's* master and crew did not identify the numerous deficiencies that existed in the ship's emergency equipment before it departed Singapore. As a result, they were not aware that the ship was unseaworthy with respect to critical safety equipment.
- *Petra Frontier's* master and crew were supported by the ship's managers during the handover of the ship. However, the managers did not require the master to confirm that the ship was, in his opinion, seaworthy before it was allowed to depart Singapore.
- While *Petra Frontier* had undergone an initial flag State inspection on 4 May 2009 and routine class surveys, the most recent being a class survey completed on 12 August 2009, neither authority was aware that the ship was unseaworthy in relation to critical safety equipment when it departed Singapore. [*Minor Safety Issue*]
- Used rags had not been disposed of correctly; instead, they had been left lying on top of the chemical drums stored near the towing pin hydraulic unit.

3.3 Other safety factors

- *Petra Frontier's* Inmarsat-C system was not set up so that automated distress messages were forwarded to the Perth, Western Australia, Land Earth Station (LES), the appropriate LES for the receipt of distress messages from ships operating in Australia's search and rescue region.
- Inter-personnel factors and a lack of trust between the various working groups on board *Petra Frontier* may have interfered with their ability to work as a cohesive team while responding to the fire.
- Drums of oils and chemicals were not stored appropriately on board *Petra Frontier*. They were stored on the deck in the steering compartment and, while the crew had lashed them in place, they were not stored securely. Furthermore, the space was not protected by a fixed fire extinguishing system.
- It is possible that the steering compartment fire detectors did not activate before the fire was visually detected by the crew because, in the early stages of the fire's development, the smouldering rags did not produce a large amount of smoke and the exhaust fans may have been drawing the smoke away from the detectors.

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

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

4.1 Petra Marine Australia

4.1.1 Drill schedule

Minor safety issue

Petra Frontier's safety management system contained procedures outlining how fire and abandon ship drills should be carried out in accordance with SOLAS and Marshall Islands requirements. However, it also contained a drill schedule that provided some contradictory information.

Response from Petra Marine Australia MO-2009-009-NSA-019

Petra Marine Australia recognises that the drill schedule may have lead to some confusion and that this document will be amended accordingly.

ATSB assessment of response

The ATSB is satisfied that the action proposed by Petra Marine Australia will adequately address the safety issue.

4.2 American Bureau of Shipping

4.2.1 Seaworthiness

Minor safety issue

While *Petra Frontier* had undergone an initial flag State inspection on 4 May 2009 and routine class surveys, the most recent being a class survey completed on 12 August 2009, neither authority was aware that the ship was unseaworthy in relation to critical safety equipment when it departed Singapore.

Response from the American Bureau of Shipping MO-2009-009-NSA-020

The American Bureau of Shipping advised the ATSB that:

The class surveys of the PETRA FRONTIER in Singapore from 7 to 12 August 2009 were annual surveys which generally call for visual examination of machinery and equipment. Even if there had been more detailed surveys, similar to the renewal surveys, they would not have identified many of the deficiencies, some of them caused by subsequent work on the vessel.

Furthermore, the American Bureau of Shipping stated that:

Under ABS Rules, any damage, failure or deterioration of the hull, machinery or equipment of an ABS-classed vessel which affects or may affect classification is to be reported to ABS by the vessel owner at first opportunity. ABS received no notification of malfunctions of the vessel's fuel oil purifier, oily water separator or steering gear until advised of the 16 September 2009 PSC detention of the vessel. Nor was ABS advised of the early September attempted repairs to machinery items and the steering system, as also required by ABS Rules.

ATSB safety advisory notice MO-2009-009-SAN-021

The Australian Transport Safety Bureau advises that the American Bureau of Shipping should consider the safety implications of this safety issue and take further action where considered appropriate.

4.3 Marshall Islands Registry

4.3.1 Seaworthiness

Minor safety issue

While *Petra Frontier* had undergone an initial flag State inspection on 4 May 2009 and routine class surveys, the most recent being a class survey completed on 12 August 2009, neither authority was aware that the ship was unseaworthy in relation to critical safety equipment when it departed Singapore.

Response from the Marshall Islands Registry MO-2009-009-NSA-022

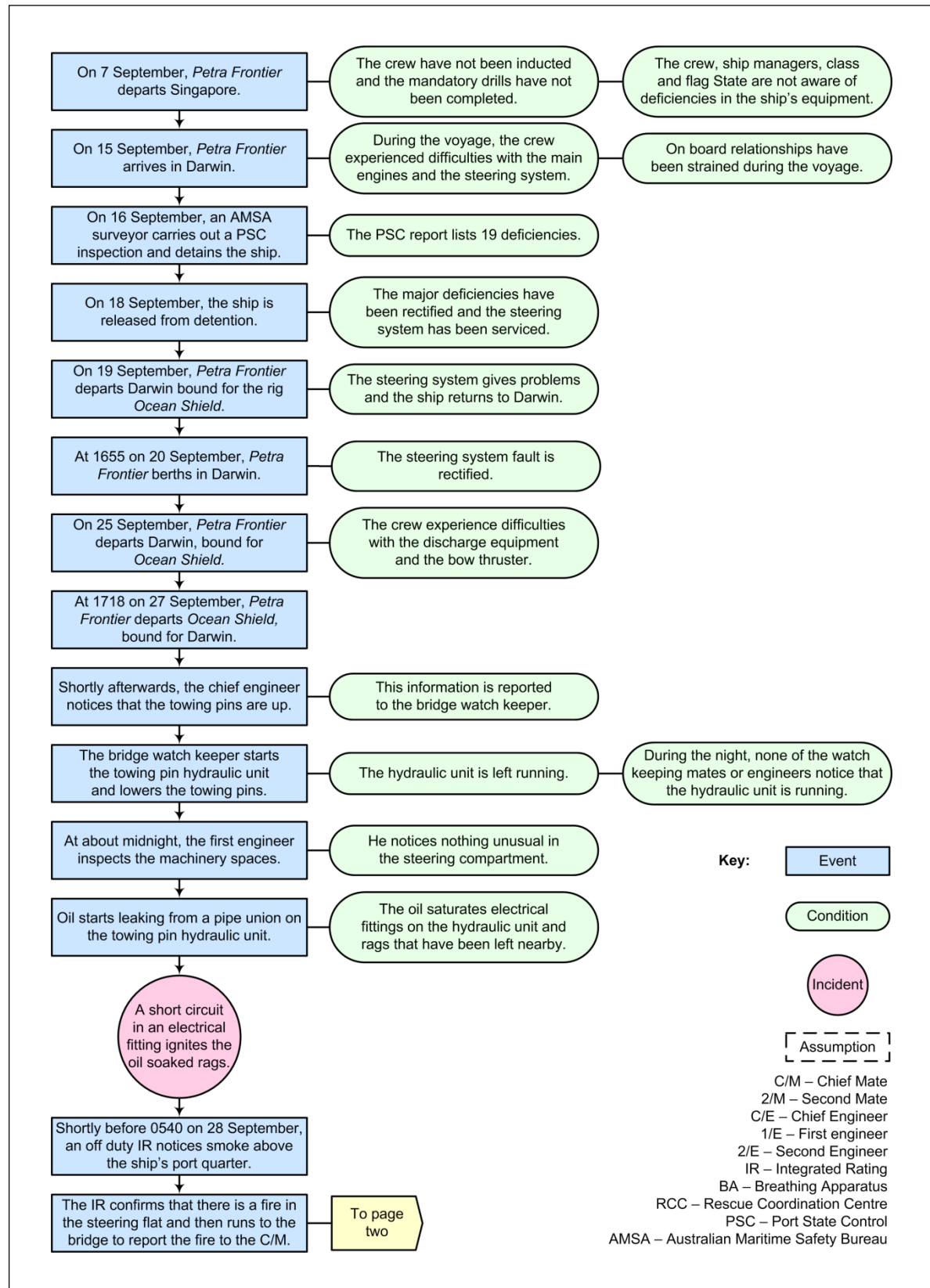
The Marshall Islands Registry has reviewed the initial flag State inspection carried out by its contracted surveyor on board *Petra Frontier* on 4 May 2009. As a result of this review, it has been decided that the contractor will not be engaged to carry out inspections in the future.

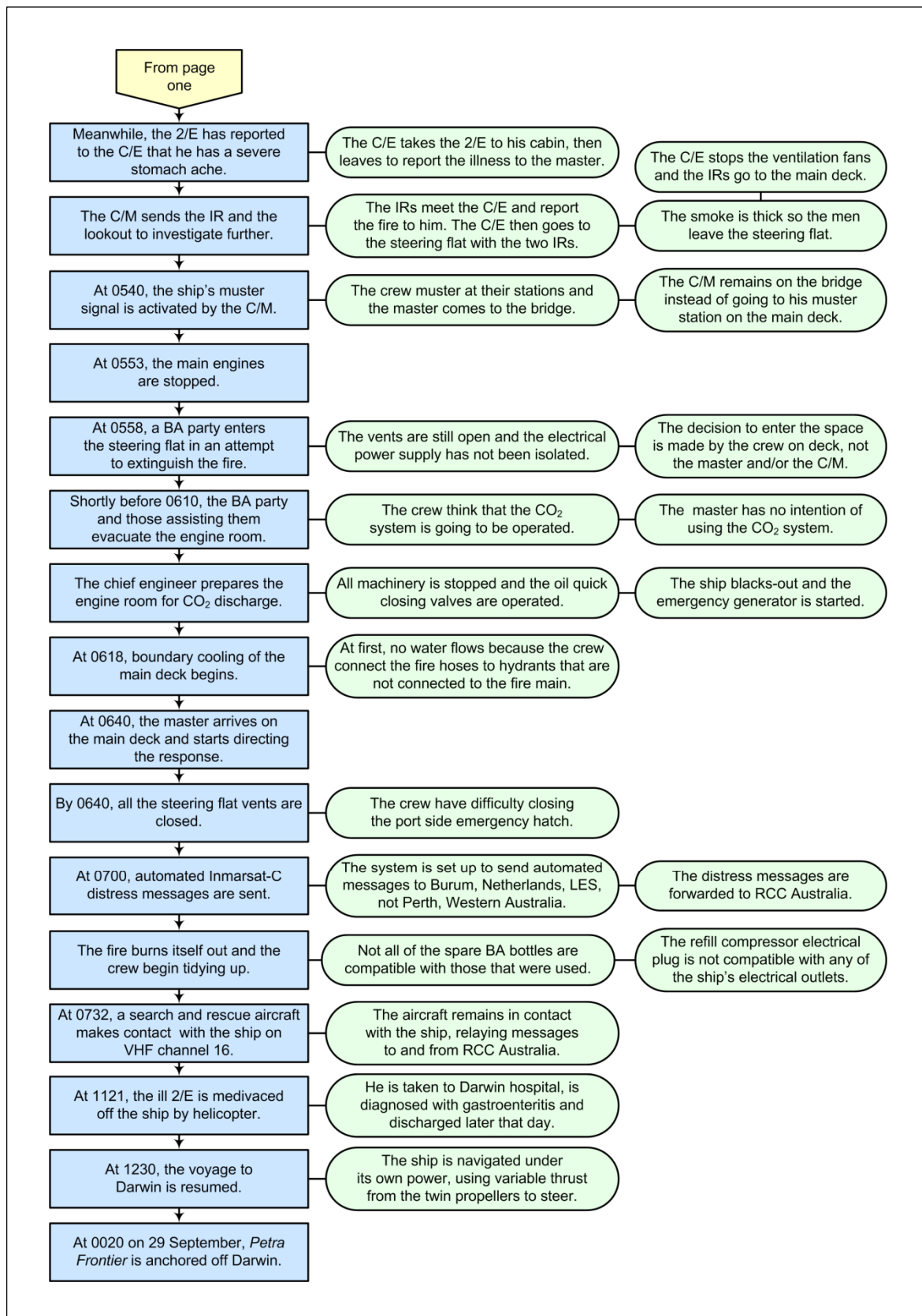
Petra Frontier and its owners remain under close scrutiny by the Marshall Islands Registry. A flag State representative inspected the ship in Darwin on 3 October 2009 and follow up visits were carried out in Singapore between 24 and 30 October. Further visits were also carried out up until the time the ship departed Singapore. The ship has since been inspected on 10 March 2010 and 25 September; and the next inspection is planned for April/May 2011.

ATSB assessment of response

The ATSB is satisfied that the action taken by the Marshall Islands Registry will adequately address the safety issue.

APPENDIX A: EVENTS AND CONDITIONS





APPENDIX B: SHIP INFORMATION

Petra Frontier

IMO Number	9509190
Call sign	V7QD6
Flag	Marshall Islands
Port of Registry	Majuro
Classification society	American Bureau of Shipping (ABS)
Ship Type	Anchor handling tug supply vessel
Builder	Fujian Crown Ocean Shipbuilding Industry, China
Year built	2008
Owners	Mount Bubu, Marshall Islands
Ship managers	Petra Marine Australia
Gross tonnage	1,706
Net tonnage	511
Deadweight	1,752 tonnes
Light draught	2.88 m
Length overall	60.0 m
Length between perpendiculars	53.9 m
Breadth	16.00 m
Moulded depth	6.0 m
Engine	2 x Yanmar 6EY26
Total power	3,840 kW
Speed	13 knots
Crew	11

APPENDIX C: SOURCES AND SUBMISSIONS

Sources of Information

The master and crew of *Petra Frontier*

Petra Marine Australia

The Northern Territory Fire and Rescue Service

References

The International Convention for the Safety of Life at Sea (SOLAS), Consolidated Edition 2009.

The Australian Global Maritime Distress and Safety System (GMDSS) Handbook, October 2008.

Capt A.G.W. Miller, *Dictionary of Nautical Words and Terms*, Fourth Edition, 2002

Submissions

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

A draft of this report was provided to *Petra Frontier*'s master, chief mate, second mate, chief engineer, cook and three integrated ratings, Petra Marine Australia, the Marshall Islands Registry, the American Bureau of Shipping (ABS) and the Australian Maritime Safety Authority (AMSA).

Submissions were received from *Petra Frontier*'s master, second mate, chief engineer, two integrated ratings and cook, Petra Marine Australia, the Marshall Islands Registry, ABS and AMSA. The submissions have been included and/or the text of the report was amended where appropriate.

Independent investigation into the steering gear compartment fire on board the Marshall Islands registered anchor handling tug *Petra Frontier* at sea off Darwin, Northern Territory on 28 September 2009.