Australian Transport Safety Bureau

ATSB TRANSPORT SAFETY REPORT
Marine Occurrence Investigation No. 251
MO-2008-003
Final

Independent investigation into the disablement and subsequent grounding of the Sierra Leone registered products tanker

Breakthrough

at the Cocos (Keeling) Islands

12 February 2008

Australian Government

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Abstract

In September 2007, the crew of the Sierra Leone registered tanker *Breakthrough* joined the ship in China to prepare it for delivery to its new Nigerian owner. On 7 January 2008, the ship sailed from China.

On 20 January, the main engine began operating poorly after it was changed over from diesel to intermediate fuel oil because the fuel had not been effectively heated or purified. After drifting in the Indian Ocean for 21 days, the ship made its way to the Cocos (Keeling) Islands. At 1350 on 11 February, *Breakthrough* anchored off Direction Island in the Cocos Island group.

On 12 February, the weather deteriorated significantly and the ship started to drag its anchor. The master ordered a second anchor let go and ran the main engine at dead slow ahead to ease the load on the anchor cables. The main engine could not provide sufficient thrust to prevent the anchors from dragging and, at 1545, *Breakthrough*'s stern grounded, damaging the steering gear. On 13 February, the ship was successfully refloated and on 28 February, it was towed to Singapore for repairs.

The ATSB investigation found that the ship's owner did not implement an effective safety management system and did not provide sufficient support to the ship's master as required by the International Safety Management Code. The flag State's statutory certificates were issued by a management company solely with the purpose of allowing the ship to sail on an international voyage and did not appropriately represent the ship's ownership, operation or management. The ATSB also found that the ship's officers did not have adequate knowledge and experience to undertake the delivery voyage and did not effectively utilise their time before leaving China to familiarise themselves with the ship and its systems. The ATSB has issued one safety recommendation and three safety advisory notices.

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

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

Purpose of safety investigations

The object of a safety investigation is to enhance safety. To reduce safety-related risk, ATSB investigations determine and communicate the safety factors related to the transport safety matter being investigated.

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

Developing safety action

Central to the ATSB's investigation of transport safety matters is the early identification of safety issues in the transport environment. The ATSB prefers to encourage the relevant organisation(s) to proactively initiate safety action rather than release formal recommendations. However, depending on the level of risk associated with a safety issue and the extent of corrective action undertaken by the relevant organisation, a recommendation may be issued either during or at the end of an investigation.

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

When the ATSB issues a safety recommendation, the person, organisation or agency must provide a written response within 90 days. That response must indicate whether the person, organisation or agency accepts 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.

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

The Sierra Leone registered products tanker[1], *Breakthrough*, was built in Rui'an, China in 2006 and was laid up until it was bought by Jevkon Oil and Gas, Nigeria. In September 2007, a delivery crew joined the ship to prepare it for its delivery voyage to Nigeria.

On 24 December, the ship's statutory certificates and safety management system were supplied to the ship by a flag State representative. The documentation applied for the single delivery voyage only. However, it did not appropriately represent the ship's ownership, operation or management.

On 27 December, the ship bunkered both marine diesel oil (MDO) and intermediate fuel oil[2] (IFO) for the voyage. There was insufficient MDO on board the ship for the whole voyage and so the main engine would need to run on IFO for most of the voyage. The ships IFO tanks were not cleaned before fuel was bunkered.

On 7 January, the ship sailed from China, bound for Nigeria.

On 20 January, about 2 days after entering the Indian Ocean, the main engine fuel system was changed over from MDO to IFO for the first time. The ship's engineers had not made adequate preparations for using the IFO and, after changing over to IFO, the fuel system filters needed frequent cleaning because the fuel had not been sufficiently heated and had probably not been effectively purified. During attempts to rectify the problem, most of the ship's reserves of MDO were contaminated with IFO.

From this point, the ship made little progress towards its destination and the master decided to drift in the Indian Ocean while waiting for the ship's owner to organise the delivery of clean fuel. However, the owner did not arrange clean bunkers or provide any other assistance. While adrift, the crew almost ran out of food and clean drinking water before the decision was made to slow steam towards the Cocos (Keeling) Islands where it was hoped that sufficient fuel could be obtained to enable the ship to return to Jakarta for full MDO bunkers.

At 1350[3] on 11 February, *Breakthrough* anchored off Direction Island in the Cocos Island group, after drifting in the Indian Ocean for 21 days.

On 12 February, the weather deteriorated significantly and the anchor began to drag. The master ordered the other anchor let go and ran the main engine at dead slow ahead to reduce the load on the anchor cables. At 1545, despite these measures, *Breakthrough*'s stern grounded, damaging the steering gear.

On 13 February, the ship was successfully refloated. On 28 February, it departed the Cocos (Keeling) Islands, under tow, bound for Singapore for repairs.

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1 A ship designed to carry oil refinery products such as petroleum or lubricating oil, in contrast to a crude oil tanker.

2 A residual fuel oil with a specific gravity of about 0.98 and a kinematic viscosity of 180 cSt at 50°C.

3 All times referred to in this report are ship's times. In China, the ship's time was Coordinated Universal Time (UTC) + 8 hours. When the fuel was changed over and at Cocos Islands, ship's time was UTC + 6 ½ hours.

As a result of this investigation, the ATSB has identified four safety issues:

- The International Safety Management (ISM) Code requires ship owners to ensure that each ship's master is given all necessary support to fulfil their duties. However, Jevkon Oil and Gas did not provide the necessary support either before the commencement of the delivery voyage or after the ship's crew began having difficulties with the main engine's fuel and started drifting in the Indian Ocean.
- The ship's safety management system was inadequate. Had Jevkon Oil and Gas implemented an effective safety management system on board *Breakthrough*, the risk of an incident such as the one that occurred on the delivery voyage would have been reduced.
- The ship's certification was issued by a management company to itself on behalf of the Republic of Sierra Leone, solely for the purpose of allowing the ship to sail on an international voyage and it did not represent the ship's actual management or that any effective inspections of the ship or audits of the ship's safety management system had taken place.
- The operation of the ship's systems and the decisions made by the ship's senior officers suggests that they did not have sufficient relevant knowledge and experience to safely undertake *Breakthrough*'s delivery voyage and they did not effectively use the time spent in China, standing by the ship, to acquire the necessary knowledge.

The ATSB has issued one safety recommendation and three safety advisory notices.

1 FACTUAL INFORMATION

1.1 *Breakthrough*

Breakthrough (Figure 1) is a products tanker that was built in 2006 by Rui'an Jiangnan Shiprepair and Shipbuilding Company, China, for Chinese coastal trading. Originally named *Xing Long Zhou 196*, the ship was purchased by Jevkon Oil and Gas, Nigeria, in 2007 with the intention of operating it on the Nigerian coastal trade and renamed *Breakthrough*.

Breakthrough has an overall length of 117.4 m, a breadth of 16.5 m and a deadweight of 7,032 tonnes at its summer draught of 6.9 m. It has a gross tonnage of 4,393. The ship has ten cargo tanks, five each on the port and starboard sides of the ship, and two slop tanks. All of the tanks are located forward of the accommodation.

Figure 1: *Breakthrough*

At the time of the incident, the ship was registered in the Republic of Sierra Leone, managed by Capricorn Maritime, Nigeria but was not listed with any classification society. All the ship's interim certificates, valid only for the single delivery voyage from Zhoushan, China to Lagos, Nigeria, were issued in Zhoushan on 24 December 2007 by New United (International) Marine Services on behalf of the Government of the Republic of Sierra Leone.

Breakthrough's navigation bridge comprised a combined wheelhouse and chartroom. The ship was equipped with a range of navigational equipment, suitable for a vessel undertaking coastal voyages, in accordance with SOLAS[4] requirements. The equipment included two radars, an Automatic Information System (AIS) unit, HF and VHF radio equipment and an Inmarsat F satellite communications system. A global positioning system (GPS) unit and a gyro compass were installed before the ship sailed from China.

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

Propulsion was provided by a single Guangzhou 8320 ZCD-6, eight cylinder, medium speed diesel engine that delivered 2,060 kW through a reduction gearbox to a single, fixed pitch propeller. This gave the ship a service speed of about 10 knots[5] at an engine speed of about 500 rpm. The ship's main engine was designed to run using either marine diesel oil (MDO) or intermediate fuel oil (IFO). The main engine's normal fuel consumption was about 10 tonnes per day at full load and about 1 tonne of MDO was used by the diesel generator per day.

Breakthrough's crew of 15 comprised a master and two mates, three engineers, an electrician, three seamen, three oilers, a welder and a cook. The master, a Togo national, was the only permanent employee of Jevkon Oil and Gas. The remainder of the crew, four Nigerian, two Myanmar and eight Chinese nationals, had been employed for the delivery voyage only.

All the mates and engineers held appropriate qualifications for their positions issued by their respective countries and the Republic of Sierra Leone had issued a Letter of Dispensation, allowing them to complete the delivery voyage using their certificates of competency, without holding Sierra Leone certificates. The master, mates and engineers all maintained a watch keeping routine of 4 hours on, 8 hours off.

Breakthrough's master had 20 years of seagoing experience. In 1994, he obtained his master's certificate of competency and since then he had served as master on various types of tankers. In 2002, he joined Jevkon Oil and Gas as master. On 25 September 2007, he arrived in Rui'an, China, to undertake the delivery voyage of the ship.

The chief engineer first went to sea as a cadet in 1985 and he had worked on a variety of vessels, including tankers and livestock carriers, before working mainly in the offshore oil and gas industry. He had just completed his certificate of competency as engineer class one in Nigeria. He was working in the offshore industry before he was contracted by Jevkon Oil and Gas for *Breakthrough*'s delivery voyage. It was the first time he had sailed as chief engineer. On 25 September 2007, he arrived in Rui'an to undertake the delivery voyage of the ship.

1.1.1 Main engine fuel system

Breakthrough's fuel bunker tanks were located in the engine room. There were four bunker tanks for IFO, with a total capacity of 123.5 m^3, and three bunker tanks for MDO, with a total capacity of 78.7 m^3. Additional fuel for the voyage was stored in the cargo oil tanks and was to be transferred into the bunker tanks using the cargo oil pumping system with a hose laid across the deck to the bunker tank filling connections.

Fuel oil purification

The IFO would normally be transferred from the bunker tanks to the fuel oil settling tanks using the fuel oil transfer pump. In the settling tank, the IFO could be heated, lowering its specific gravity, causing some of the water and heavy contaminant particles to gravitate out. Fuel from the fuel oil settling tank could then be passed through a centrifugal separator (purifier) to remove more solid contaminants and

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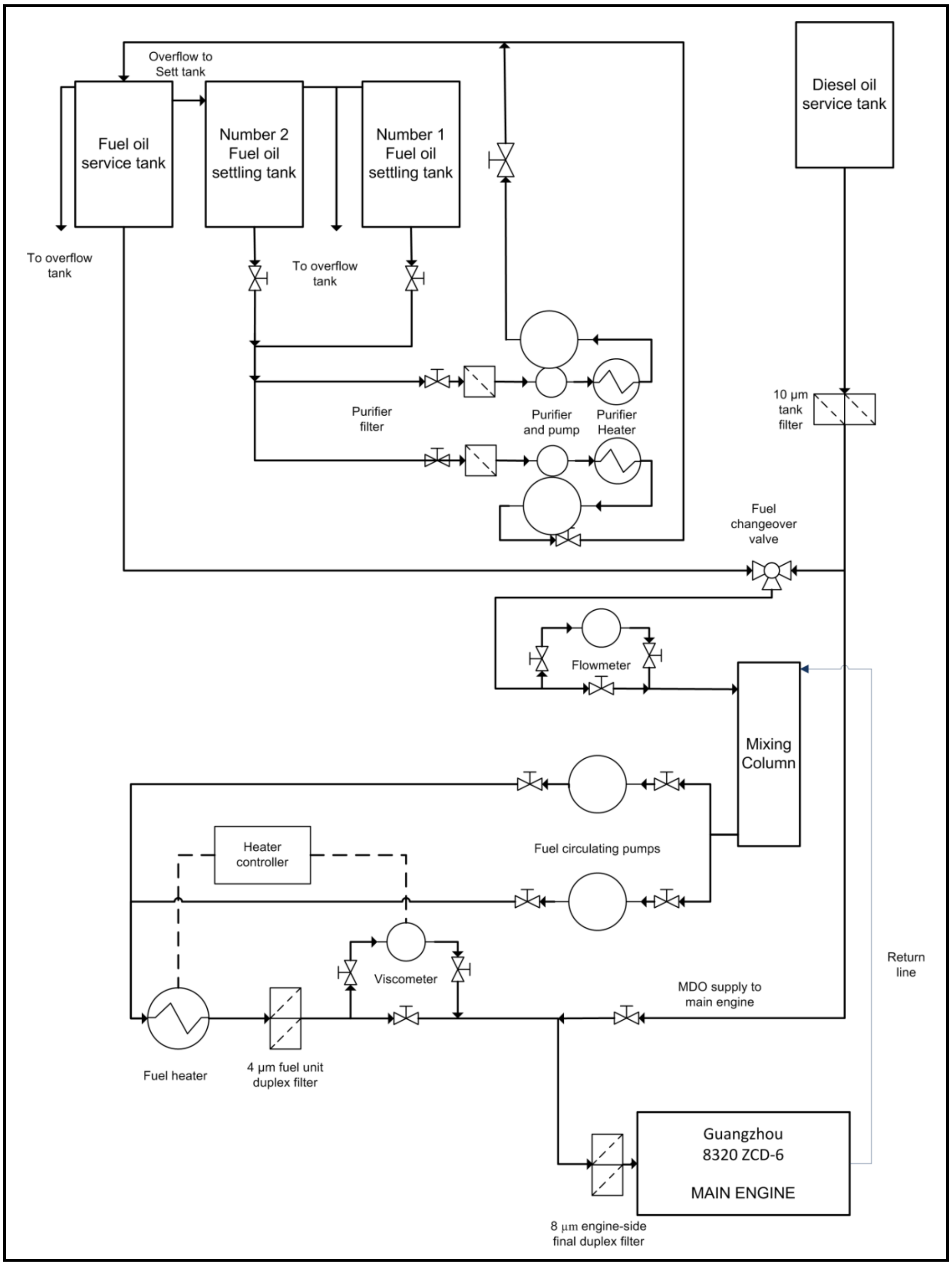
[5] One knot, or one nautical mile per hour equals 1.852 kilometres per hour.

water before it was discharged into the fuel oil service tank (Figure 2). The purifier had a rated capacity of 2,000 l/hr and, normally, fuel will overflow from the service tank back into the settling tank so that it can be re-purified, allowing the purifier to run continuously.

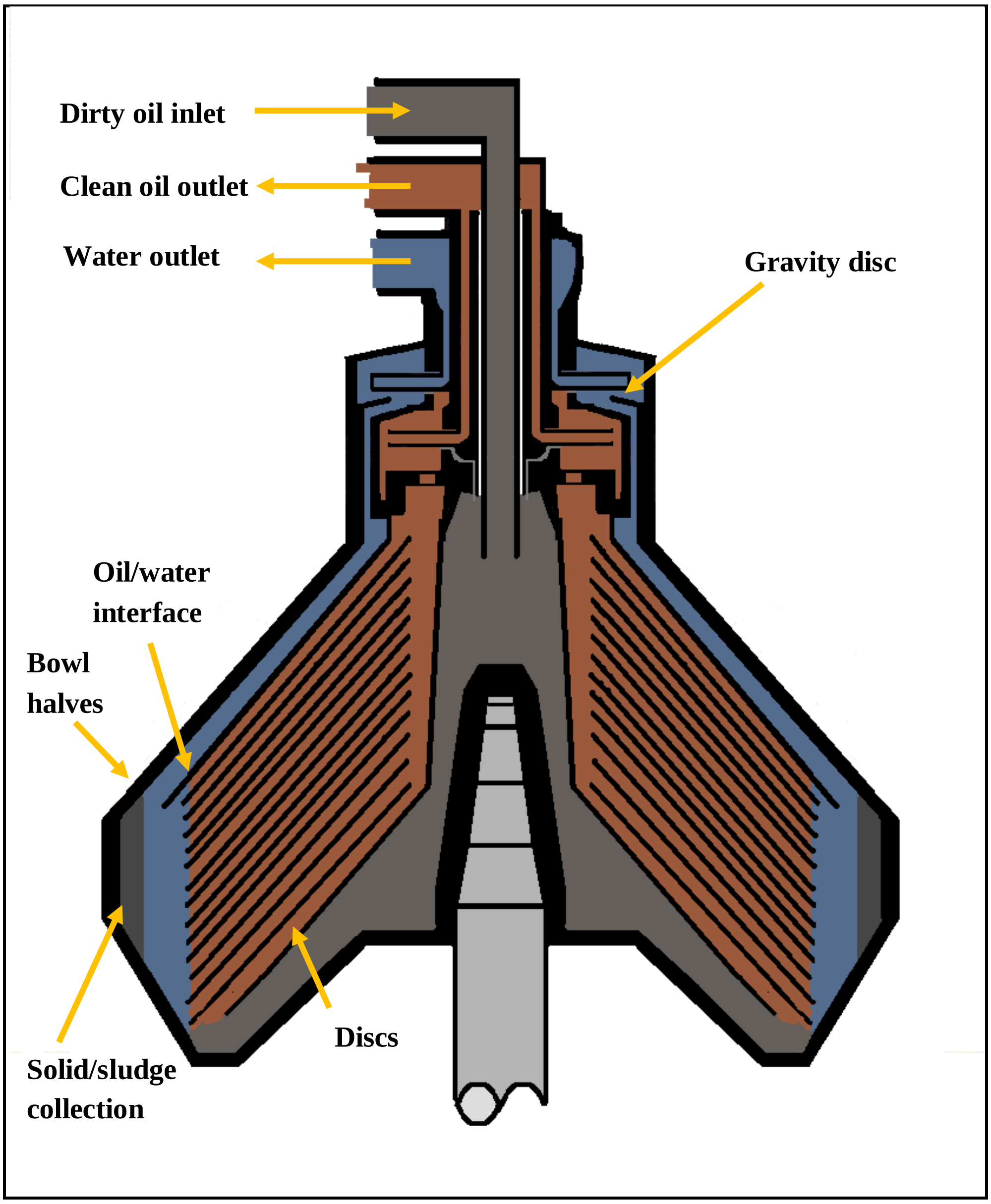
Figure 2: Main engine system schematic diagram



Purifiers are designed to separate materials or liquids of higher density from the process liquid using centrifugal force. In the case of a fuel oil purifier, the process liquid is fuel oil and the 'heavy phase' is any water or solid particles in the fuel with a density higher than that of the fuel. Purifiers rely on the different relative densities of the oil and the water or solid contaminants and the action of centrifugal force to separate the water and contaminants from the oil.

The purifier bowl (Figure 3), is shaped like two cones joined at their bases and contains a stack of conical discs, spins at about 8,000 rpm. This produces a centrifugal force of up to about 5,000 times the force of gravity.

Figure 3: Fuel oil purifier



Dirty oil is fed into the bowl where the centrifugal force results in the water and heavier particles being flung outwards, towards the periphery of the bowl. Any water is allowed to continuously discharge through the water outlet connection and the lighter, clean oil is allowed to discharge through the clean oil outlet connection. The solids and sludge accumulate at the outer edge of the bowl until a regular automatic de-sludge cycle temporarily opens the two bowl halves, discharging the sludge from the machine. Some water is present at the periphery of the purifier bowl at all times to seal it. The point near the periphery of the bowl where the water and the fuel oil meet is called the ‘interface’.

To optimise the cleaning of fuel oil in a purifier, the interface needs to be maintained as close to the edge of the stack of conical discs as possible. This is achieved by selecting the correct gravity disc[6] for the fuel's density. Purification also depends on operating the purifier at the correct temperature, maintaining the correct back-pressure on the purifier's oil outlet and reducing the fuel oil throughput to the lowest possible level so that the oil remains in the purifier for longer.

If the opening in the gravity disc is too large and/or the outlet line back-pressure is too high, the interface will be too close to the periphery of the bowl and fuel will be carried over into the water outlet. Conversely, if the opening in the gravity disc is too small and/or the back pressure is too low, the interface will be too close to centre of the bowl and purification will be inefficient, with water and solid contaminants being carried over in the purified fuel.

For IFO, the maximum difference between the densities of the fuel and the water occurs at a temperature of about 85°C. At 98°C, the density difference is almost the same but the viscosity of the fuel is lower, increasing the movement of solid particles towards the periphery of the purifier bowl, thus the fuel should be at this temperature to maximise the efficiency of separation. If the fuel inlet temperature is too high, above 100°C, the sealing water may begin to evaporate[7], causing the bowl seal to fail. If the fuel temperature is too low, the difference in the relative densities is lower and the interface will move closer to the centre of the bowl, reducing separation efficiency.

Fuel oil heating

Fuel from the service tank passes through the fuel unit where it is filtered and, when necessary, heated to provide the correct viscosity for injection into the main engine cylinders. This ensures that the fuel atomises properly so that clean and efficient combustion takes place in the engine. For most diesel engines, the maximum allowable inlet viscosity is between 12 and 14 cSt[8]. IFO needs to be heated to about 120°C to achieve this engine inlet viscosity but MDO has a viscosity of about 1.4 cSt and, therefore, does not need to be heated.

Breakthrough was equipped with a packaged fuel treatment unit (Figure 4) that comprised a changeover valve, a mixing column, circulating pumps, a flow meter, a duplex filter, a viscometer and a heater that used steam to heat the fuel. The fuel unit was supplied with fuel from either the diesel oil service tank or the fuel oil service tank (Figure 2).

When *Breakthrough*'s main engine was running on IFO, a viscometer could be used to measure the viscosity of the fuel being delivered to the main engine through the outlet filter. When the viscometer was running, it continuously monitored the fuel viscosity and its output control signal was used to regulate the steam supply to the fuel heater, thereby maintaining a constant viscosity. If the viscometer or controller malfunctioned, it could be by-passed and the fuel heater steam supply manually regulated to maintain a constant temperature and hence the correct viscosity.

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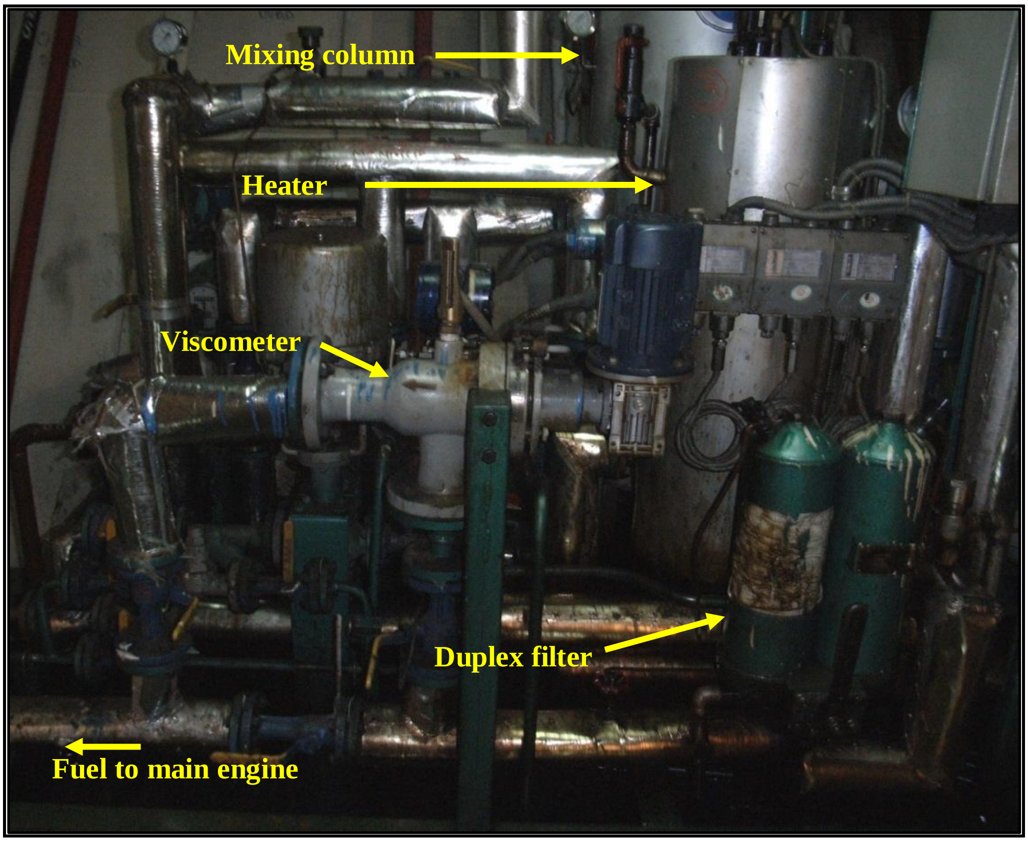
6 A metal disc inside the purifier that determines the position of the oil/water interface.

7 Clark, G.H. (1988), *Industrial and Marine Fuels Reference Book,* p21/18.

8 Centistokes, the SI unit for fluid viscosity.

Figure 4: Packaged fuel unit



Main engine fuel injectors

Breakthrough's main engine manual stated that injectors with nozzle cooling were required in order to run the engine using 'heavy diesel oil of high viscosity'. These injectors were designed to be cooled using an independent cooling module that circulates cooling oil at a temperature between 80°C and 90°C. The nozzle cooling system does not form part of the fuel transfer, purification or filtration system.

At the time of the incident, *Breakthrough*'s main engine was not fitted with nozzle cooled injectors or a nozzle cooling module.

1.2 Cocos (Keeling) Islands

The Cocos (Keeling) Island group (Cocos Islands) is an Australian Territory located in the Indian Ocean (12°10'S 96°50'E), about 1,500[9] miles northwest of Perth, Western Australia. The Cocos Islands consist of a series of 27 coral islands, covering an area of 14 km^2, formed into two large coral atolls. The islands are low lying, the highest point being only 9 m above sea level.

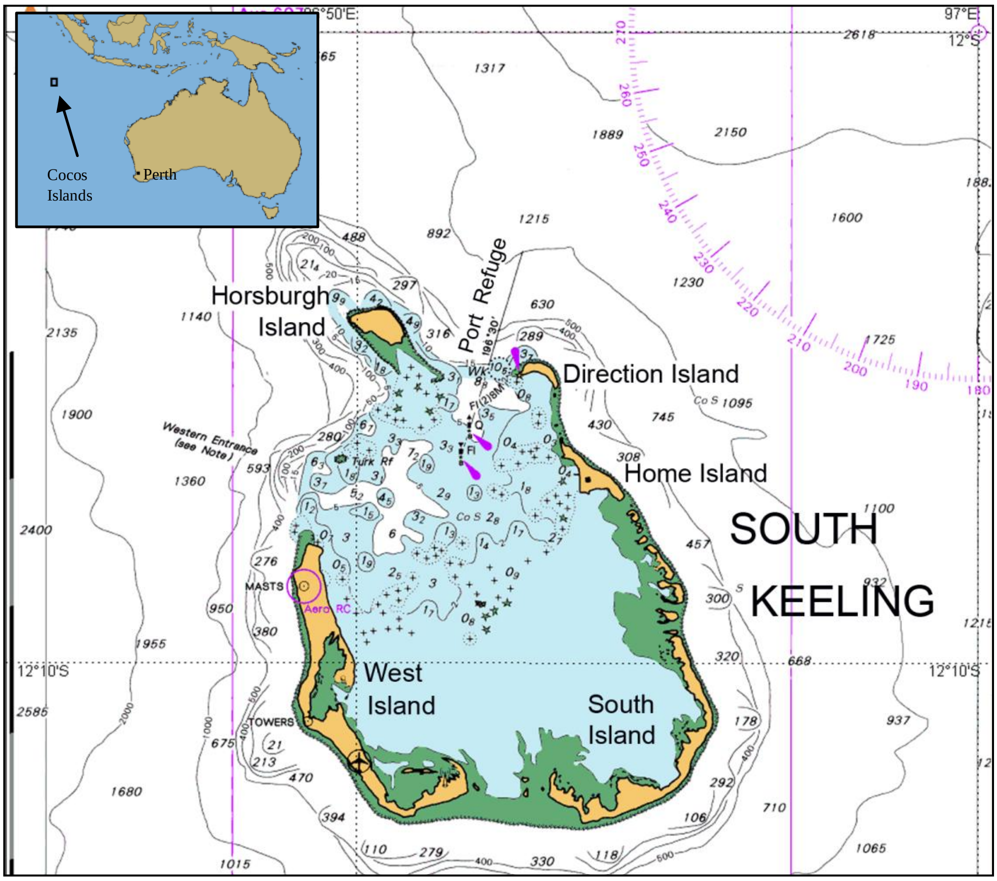
South Keeling (Figure 5) includes the two inhabited islands of Home Island and West Island, on which the airport, quarantine station and government offices are located. The islands are serviced by a limited shipping service, which brings general supplies and fuel (both diesel and petrol) to the islands. The lagoon is shallow and

[9] A nautical mile of 1852 m.

there are no berthing facilities available so the small supply ships moor to buoys located between Home and West Islands. Entry to the lagoon is from Port Refuge, which is considered a safe anchorage in fair weather, and for weather coming from the southeast. There is no pilotage service available for entry into the lagoon.

The climate is sub-tropical with mean daily maximum temperatures of about 29°C. Southeast trade winds blow most of the year. Occasionally, the islands are affected by cyclonic conditions, but they are rarely in the direct path of cyclones.

Figure 5: Section of chart Aus 606 showing South Keeling



1.3 The incident

On 21 September 2007, *Breakthrough*'s master, two engineers, an electrician and a cook arrived in Beijing, China, after travelling from Lagos, Nigeria. They were travelling on a 1 month visa and expected to stay for about 1 week in China, familiarising themselves with the ship before delivering it to Nigeria.

On 25 September, the crew travelled to Rui'an. They stayed in a hotel and, after waiting for about 2 days, they were taken to see the ship for the first time. Before leaving Nigeria, they had been told that the ship was new. However, it appeared to the crew to be in poor condition. It had not been engaged in coastal trading, having been laid up at anchor in a river since being built in 2006.

The ship's new owner travelled to China in mid October to finalise the purchase and he contracted a shipbroker to act as his shipping agent, including the provision of additional crew and the renewal of the crews' visas.

The Nigerian crew stayed in a hotel but attended the ship and noted defects which needed to be repaired before the ship's delivery. All of the ship's manuals, log books and the labels on most of the valves, switches and instruments were written in Chinese. A Chinese engineer translated many of these labels in the engine room into English for the delivery crew and the translations were written onto the equipment using a marker pen (Figure 6).

Figure 6: Fuel unit control panel

On 11 November, the chief engineer sent the shipbroker a list entitled 'Outstanding Requirements'. This included an English translation of the ship's main engine operations and maintenance manual and several other equipment manuals, wiring and piping diagrams.

Due to the number of defects found, the chief engineer urged the owner to conduct a sea trial on the ship. On 9 December, the ship's owner informed the master and chief engineer that the shipbroker would conduct a sea trial on the ship. The master and chief engineer accompanied the shipbroker and owner for the sea trial. The main engine was test run while the ship remained at anchor in the river. The owner then left the ship and returned to the hotel and no further trials were undertaken.

On 15 December, the Nigerian crew finally left the hotel they had been living in since their arrival in Rui'an and moved on board the ship. The shipbroker arranged for additional crew to supplement the master and the Nigerian crew for the delivery voyage and on 16 December, the additional crew also joined the ship in preparation for its departure.

On 21 December, the ship's crew sailed the vessel from Rui'an and up the coast to Zhoushan, China, assisted by the shipbroker and his staff. None of the ship's machinery was tested before the 200 mile voyage, apart from the engine trial on 9 December, and the main engine was run on MDO, not IFO. During the voyage, the emergency switchboard, which had not been secured to the deck, fell over. The engineers lifted it upright and welded temporary braces onto it to secure it in place. The switchboard was found to be not operational after the fall. Normally, one set of steering gear is powered from the emergency switchboard and one from the main switchboard. With the emergency switchboard non-operational, the engineers connected the power supply for one set of steering gear to the aft winch power supply instead of the emergency switchboard so that both sets of steering gear could be used.

In Zhoushan, *Breakthrough* was laid up while the crew undertook necessary work to prepare it for the voyage to Nigeria where the owner intended to effect permanent repairs. The work included installing a GPS, a gyro compass and a reverse osmosis water generating plant that discharged fresh water into the after peak potable water tank, located below the steering flat. The crew continued familiarising themselves with the ship.

The chief engineer prepared another list of urgent unresolved problems including the air-conditioning system, the fuel oil purifier, a number of electrical problems, the emergency switchboard and the need to test the oily water separator, emergency generator, the emergency fire pump and the new water generating plant. There was no response to this list.

In preparation for the voyage, 300 tonnes of MDO was ordered which the master and chief engineer had calculated to be enough to take the ship across the Indian Ocean to the African coast where additional bunkers could be obtained to complete the voyage. The ship's owner wanted to complete the voyage using IFO because of the high cost of MDO. The chief engineer informed the owner that modifications needed to be made before the main engine could be run using IFO. The ship's owner did not make the necessary main engine modifications but he reduced the MDO order to 250 tonnes and ordered 400 tonnes of IFO so that the entire voyage could be completed, using mostly IFO, without the need to take more bunkers during the voyage.

The ship's bunker tank capacity was insufficient for the intended quantity of fuel so the master and chief engineer decided to store the additional fuel in cargo oil tanks. The fuel would be transferred to the bunker tanks in the engine room as required using the ship's cargo oil pumps and hoses laid across the main deck.

On 27 December, the crew bunkered the MDO and the IFO. About 25 tonnes of MDO was bunkered into each engine room MDO bunker tank and the remainder was put into number five port cargo oil tank. Similarly, the engine room IFO bunker tanks were filled and the remaining 300 tonnes was put into number three starboard cargo oil tank.

On 7 January, *Breakthrough*'s crew made final preparations for departure from Zhoushan. The after peak potable water tank was very dirty so the crew purchased large quantities of bottled water for the voyage. The ship was carrying no cargo and its departure draughts were 3.0 m forward and 5.0 m aft. The fuel oil purifiers were not operational, the fuel oil treatment plant had not been tested and the main engine had not been run on IFO. The bilge system and oily water separator had not been tested and the air-conditioning plant and oil-fired section of the composite boiler[10] were also not operational. After nearly 3 months of preparation, the crew were not completely familiar with the ship's systems and the translated equipment manuals and other documents had not been received on board the ship. At this time, in the cold ambient conditions [11], the IFO had solidified in the bunker tanks.

At 1600, a harbour pilot boarded the ship for the transit from Zhoushan to sea. The anchor was weighed and the ship began the voyage to Nigeria with the main engine running on MDO. At 1732, the pilot disembarked and by 1936, the main engine's speed had been increased to 480 rpm.

The master's voyage plan was to keep *Breakthrough* close to land in case any assistance was needed. The ship would pass through the Malacca Strait on the way to Sri Lanka, across to the east coast of Africa and then around the coast to Nigeria. The 9,500 mile voyage was expected to take about 40 days.

At 0800 on 8 January, the engineers increased the main engine speed to 500 rpm and the ship made good about 10 knots. At 0400 on 9 January, the auto pilot failed and the master changed over to hand steering. Between 9 and 14 January, as the ship sailed down the coast of China and south-west towards Singapore, the engineers maintained their normal watch routine, carrying out routine inspections and minor repair and maintenance tasks.

When the engineers attempted to use the ship's two fuel oil purifiers, they discovered several system components were missing and that one purifier bowl was jammed. On 14 January, the engineers commissioned a fuel oil purifier and began purifying IFO from the fuel oil settling tank to the fuel oil service tank. The steam required for the purifier fuel oil heater was provided by the composite boiler using the heat from the main engine exhaust gas. The steam pressure was recorded in the engine room log book as 0.35 MPa[12].

By 15 January, the engine room bilge holding tank was nearly full. The engineers had not tested the oily water separator and were reluctant to use it so the chief engineer decided to transfer the tank's contents into number two port cargo oil tank. The engineers opened the bilge holding tank's manhole cover and pumped its contents across the ships main deck to the cargo tank using a hose and a portable pump.

As the ship neared Singapore, the master decided to change the voyage plan and sail directly through the Sunda Strait, Indonesia and across the Indian Ocean to Africa. This would reduce the voyage by about 1,000 miles, or 4 days steaming.

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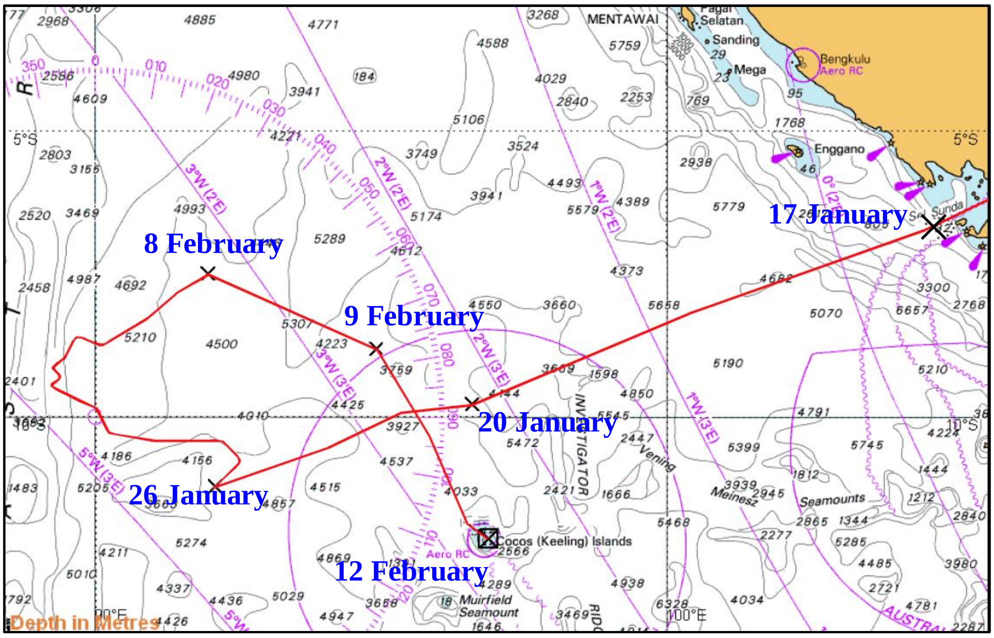
10 A composite boiler has two sets of steam generating tubes and generates steam either from main engine exhaust gas or from an oil-fired furnace.

11 The mean ambient temperature range for the region for January is from about 0.5°C to 7.7°C.

12 One Mega Pascal (MPa) equals ten bar or approximately ten atmospheres.

On 16 and 17 January, the engineers continued their watch keeping routine and they carried out minor repair and maintenance work on the engine room equipment. At 2345 on 17 January, *Breakthrough* exited the Sunda Strait and entered the Indian Ocean (Figure 7).

Figure 7: Section of navigation chart Aus 4071 showing *Breakthrough*'s track in the Indian Ocean



On 18 January, the chief engineer stopped the main engine so that a leaking steam drain trap on the boiler could be repaired. After he had manufactured and fitted an improvised drain trap, the main engine was restarted and the passage was resumed.

On 20 January, the chief engineer informed the master that 'D-Day has come' because it was time to run the main engine on IFO. At about 1000, he changed over the fuel system from MDO to IFO. Almost immediately, the differential pressure across the main engine fuel filters[13] began to rise.

At 1310, the chief engineer stopped the main engine because the engineers needed to clean the fuel unit filters about every 10 minutes because of the high differential pressure. At 1425, the engine was restarted and was run at reduced speed, between dead slow ahead and half ahead, in an attempt to reduce the fuel flow through the filters, thereby, reducing the frequency that they needed to be cleaned. However, the filters still needed to be cleaned frequently so, at 1936, the chief engineer stopped the main engine and the ship began to drift. The wind was force[14] two (4 – 6 knots) from the south and the seas were slight on a 1 m swell. Visibility was good, about 10 miles.

The master tried to contact the ship's owner using the satellite telephone to report the fuel system problems but he was unsuccessful because the satellite communications system was not functioning correctly. He tried to call Jakarta

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13 The difference between the filter's inlet and outlet pressures. A high differential pressure indicates that the filter may be blocked.

14 The Beaufort scale of wind force, developed in 1805 by Admiral Sir Francis Beaufort, enables sailors to estimate wind speeds through visual observations of sea states.

Radio using the ship's high frequency (HF) radio, again without success. He finally sent a message to the owner using a passing ship as a communications relay.

Throughout 21 January, the engineers tried to solve the fuel system problems so that the main engine could be run on IFO. At 1600, the main engine was restarted and the voyage resumed. At 1928, it was stopped again because of a leaking starting air valve. The valve was replaced and the ship drifted overnight to allow the engineers to rest.

On 22 January, the engine was run between 0805 and 2349 with the filters being cleaned frequently. At 1200 and 1600, the main engine fuel oil inlet temperature was recorded in the engine room log book as 85°C and 96°C respectively, these were the only occasions that the fuel temperature was recorded during the voyage.

At 0700 on 23 January, the engine was started again. At 1718, it was stopped because the number two cylinder exhaust temperature was high. The injector was replaced and the ship drifted overnight. The wind had increased to force three (7 to 10 knots) and the seas were slight with the ship rolling uncomfortably on a heavy swell.

Following the failure of the fuel injector, the engineers decided to clean out the engine room fuel oil settling and service tanks and start with a clean batch of fuel. On 24 January, they rigged a temporary fuel transfer arrangement, using the fuel transfer pump and a long hose, and pumped about 79 tonnes of IFO from the engine room tanks into number five starboard cargo tank.

On 25 January, once the fuel oil settling and service tanks were empty, the engineers inspected and cleaned them. The crew then attempted to transfer some IFO from the cargo oil tanks back into the cleaned engine room settling tanks using the cargo oil pumps and a hose connected to the discharge manifold. When the pump was started, no fuel discharged into the hose. The crew opened several tank valves in an attempt to solve the problem by 'trial and error'. Before they realised what was happening, several tonnes of IFO had gravitated into the number five port cargo oil tank, contaminating the MDO stored there.

The engineers decided to refill the main engine settling and service tanks with contaminated MDO to see if it could be used in the main engine without problems. As a result of the contamination, the ship now had only 33 tonnes of clean MDO on board, 14 tonnes remaining in the MDO bunker tank and the remainder in the auxiliary engine settling and service tanks.

The main engine was restarted using the contaminated MDO but the filter's differential pressure began to rise again shortly afterwards. The fuel system was still full of IFO and the engineers continuously cleaned the fuel filters until the contaminated MDO had flushed the cold IFO out of the system.

One of the ship's Chinese engineers examined the writing on the side of the fuel unit filter and told the chief engineer that the 'filter was specified for MDO and not for IFO'. It was a fine, 4 µm filter whereas the main engine final filter was 8 µm (Figure 2) and the MDO tank outlet filter was 10 µm. The engineers exchanged the fine filters with the larger mesh MDO tank filters. However, they still needed to be cleaned about twice per watch. The chief engineer believed that the engine could not operate using the contaminated MDO and that the only solution to the ship's problems was to obtain clean MDO bunkers which would need to be delivered to the ship.

On 26 January, with the satellite communications system working again, *Breakthrough*'s master advised the ship's owner that supplies of clean MDO were needed urgently. He said that if the company did not arrange it within the next 48 hours, then he would be forced to activate the EPIRB[15] so that the crew could be rescued. The ship had made no progress for 5 days, drifting in the Indian Ocean for long periods of time and rolling up to 15°, and the crew's morale was getting low.

The engineers also sought advice from the shipbroker in China using the satellite communications system. The shipbroker's engineer advised the chief engineer to use the purifier 'properly' while maintaining the fuel oil temperature at the purifier inlet at about 98°C. He further advised that the main engine fuel inlet temperature should be 120°C and that, because the fuel unit heater was small, the service tank temperature would also need to be heated to about 120°C. The shipbroker's engineer also suggested that the contaminated MDO be used first. The chief engineer thought that the shipbroker's engineer was suggesting that the MDO be heated to 120°C before being used and he considered these suggestions to be 'ridiculous'. He chose to disregard them.

On 27 January, the wind was force three with a moderate sea on a heavy swell and the ship was still rolling about 15°. The air conditioning still had not been fixed and the crew's consumption of fresh water had increased in the hot and humid tropical conditions. The crew were becoming increasingly angry and frustrated with their lack of progress on the voyage.

At about 1230, the master notified the shipbroker and the ship's owner of the conditions on board and reiterated his request for clean fuel; 300 tonnes would get the ship across the Indian Ocean and 600 tonnes would get it to Nigeria. He also informed them of the situation with the crew.

The shipbroker made some enquiries and told the master that the Cocos Islands were the nearest land but there was insufficient fuel available there for the ship to continue to Africa. He also told the master that it would be difficult and expensive to transfer 300 tonnes of fuel onto a tug and to refuel the ship at sea. He added that the decision to arrange for refuelling at sea would need to be made by the ship's owner in Nigeria. Later that day, the shipbroker informed the master that the owner could not organise payment of a deposit to a tug company because it was Sunday.

At 1050 on 28 January, the shipbroker contacted the master and asked him for a status report on the ship's tanks and the ship's distance from the Cocos Islands. At that time, the ship was 420 miles from the Cocos Islands and there was a total of 306 tonnes of IFO on board, almost 100 tonnes of contaminated diesel and 33 tonnes of clean diesel for the generators. The ship had 2,248 tonnes of water ballast on board and about 92 tonnes of fresh water, most of which was in the dirty tank below the steering flat.

On 30 January, the master reported to the ship's owner that conditions on board the ship had deteriorated further. The chief engineer and some of the crew were feeling ill and had developed rashes following the tank cleaning work. Morale was low and the crew had also begun fighting amongst themselves. Both the electrician and the cook had informed the master that they wished to leave the ship at the earliest possible opportunity.

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15 Emergency Position Indicating Radio Beacon.

By 0600 on 31 January, the weather had worsened and *Breakthrough* was now rolling up to 25° each way. The chief engineer informed the master that he too wished to leave the ship at the next port.

At about 1220, the master was advised by the shipbroker that a tug and fuel supplies had been organised but that the owner had not arranged payment for these services. The master then issued the ship's owner with an ultimatum. He stated that, if action was not taken in the next 24 hours to rectify the situation on board, he would contact emergency services or salvage companies to effect a crew rescue. He would also notify the media of the plight of the crew.

In reply, the owner stated that he considered it was not safe and almost impossible to deliver any fuel to the ship while it was drifting in the Indian Ocean and that he was arranging to tow the ship to safety. He urged the master to not panic and for 'you and your crew not to take any action that would be a regret in our future'.

On 1 February, the shipbroker informed the master that a tug had been arranged in Jakarta and that the ship's owner was arranging payment to tow the ship to safety.

In an attempt to solve the ship's problems, the master contacted the owner and informed him that he thought it didn't make sense to tow a vessel that can move and all he needed was a bunker supplier to deliver sufficient fuel and that the owner should make payment for the fuel instead of towage.

The master started searching for bunker suppliers himself. He contacted a fuel company in Singapore via email and told them that his vessel was in distress about 490 miles from the Cocos Islands and that he was seeking a quote to supply 600 tonnes of MDO.

During the day, the weather eased to force two (4 to 6 knots). The swell remained heavy with the ship still rolling about 15° each way.

On 2 February, the master informed the ship's owners that the situation had worsened. The crew was now rationing food and drinking water and the bunker supplier would need to bring food and water in addition to the fuel.

On 4 February, a maritime consultant in Nigeria, who was engaged by Jevkon Oil and Gas, contacted the ship. He suggested that the crew use some of the contaminated MDO to get the ship moving and, once the IFO was heated up, change over the engine to run on the IFO. He told them that 'mistakes had been made and that the company was trying very hard to get bunkers but that the crew should do something'.

By this time, the ship had been drifting for 15 days, rolling on the heavy swell, and the crew were uncomfortable in the hot and humid conditions. They were afraid and were becoming increasingly frustrated with the lack of action by the ship's owners. The weather had deteriorated again and some minor equipment on board the ship had been damaged by the ship's motion. One of the Chinese oilers became so frustrated that he attacked some of the crew with a knife. Nobody was injured before he was subdued.

On 5 February, the ship's owner contacted the master and told him that he was trying to get help for them and the crew should 'all keep faith in God and not lose hope'.

The ship owner's consultant also contacted the ship and reiterated that they should run the engine on the contaminated fuel to get closer to a friendly port. He acknowledged that the fuel was not as good as expected but the crew should have complained about it while the ship was still in China and that it was too late to complain now. He stated, ‘anyway, please try to move out. Don’t let owner spend too much money on something all of us should have avoided before the vessel sailed from China.’

On 6 February, the engineers tried unsuccessfully to clean the contaminated MDO using some spare filter cartridges from the freshwater system.

The master again contacted the owner and informed him that the Chinese crew refused to work if the ship did not move. After 17 days adrift, the crew demanded to know when the company was going to provide the ship with supplies and clean MDO and when was the master going to send a distress message.

At about 1740, the ship’s owner informed the master that he had arranged for 150 tonnes of MDO, 50 tonnes of fresh water and food to be supplied to the ship through a company in Sri Lanka and that the owner’s bank was arranging to transfer the necessary funds.

On 7 February, the crew were again restless and the master struggled to calm them. The crew asked the master to find out the exact date of delivery for the fuel and they again suggested that he send a distress message.

Not having enough MDO to complete the voyage, the master decided to turn the ship around and return to Jakarta, Indonesia, via the Sunda Strait so that MDO could be bunkered. At 1600 on 8 February, the engineers restarted the main engine using the contaminated MDO and the ship was able to make good about 10 knots. The engineers continued to clean all of the fuel filters about twice per watch. The ship was about 950 miles, or 4 days steaming, from the Sunda Strait.

At 1000 on 9 February, the engineers stopped the main engine because the number two fuel injector was not working properly. They did not have a spare injector so the fuel control rack for this injector was set at zero and at 1200, the engine was restarted and run at reduced speed. The ship was able to maintain between 4 and 5 knots with the engine running at reduced speed.

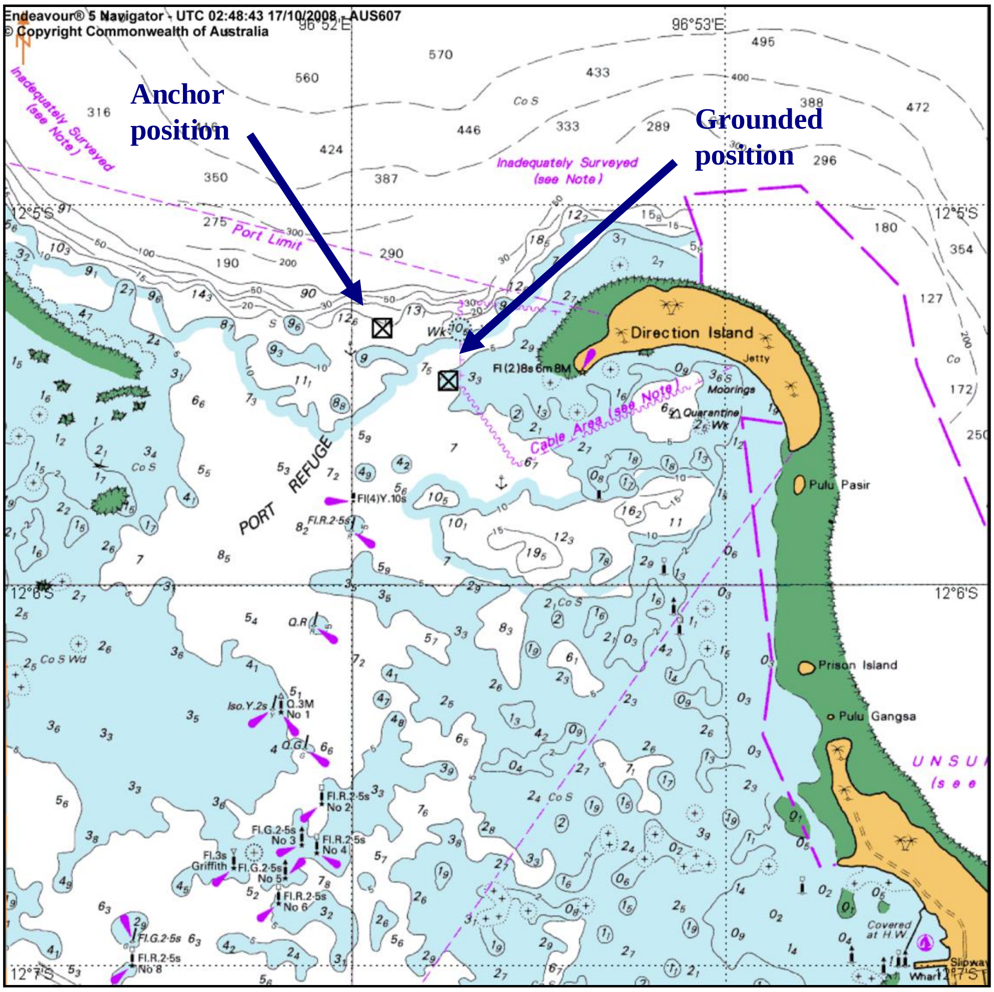
With the main engine running poorly and the Cocos Islands being closer than the Sunda Strait, the master decided to take the ship to the Cocos Islands. At 1345, he altered course towards the Cocos Islands.

At 1000 on 11 February, the master contacted the ship’s owner and informed him that the ship was about 20 miles from the Cocos Islands. His message included a list of spare parts required to restore the main engine to full capability.

The master did not have a chart for the Cocos Islands so, when he estimated that the ship had about 10 miles to go, he made a distress call using VHF Channel 16. This call was answered by the Australian Federal Police (AFP) on West Island, the main island of the South Keeling group, The master was directed towards the north-western tip of Direction Island, where ships usually anchored.

At about 1350, *Breakthrough*’s port anchor was dropped in position 12°08.42’S 96°52.17’E, off Direction Island (Figure 8). While the ship was at anchor, the master, chief and second mates maintained anchor watches.

Figure 8: Section of navigation chart Aus 607 showing *Breakthrough*'s anchor and grounding position



On 12 February, the weather deteriorated dramatically. The wind swung around to the west-south-west and increased in strength.

While the master was eating lunch, he heard the wind increase in strength. He went to the bridge and saw that the ship had begun to drag its anchor so he ordered the starboard anchor let go.

At 1259, the anchors were still dragging so the main engine was started and run at dead slow ahead to ease the strain on the anchor cables. However, the anchors continued to drag.

At 1545, the ship's stern grounded on shoal water off the western tip of Direction Island (Figure 8). The steering gear was damaged when the stern pounded onto the reef (Figures 9 and 10) and the main engine was stopped because the propeller blades were striking the reef.

The master made a distress call using VHF Channel 16, to which the AFP responded. At 2130, all of the crew, with the exception of the master, were evacuated from the ship. Before leaving the ship, the chief engineer started the fire pump so that the master could fill the number one cargo tanks using a fire hose to trim the ship by the head.

Figure 9: Damaged steering gear

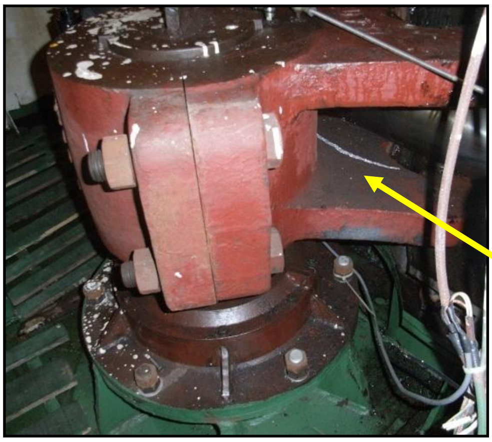
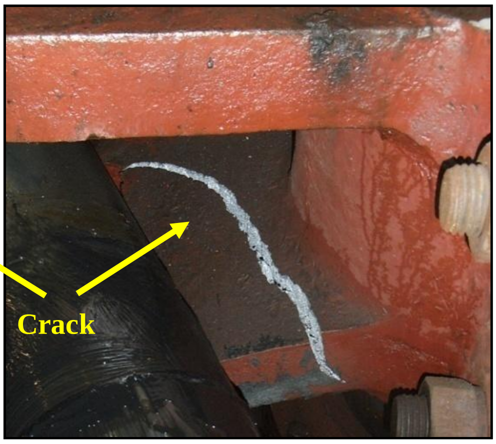


Figure 10: Close up view of crack



An inspection of the ship revealed that the hull had not been breached but a small amount of water was entering the ship through the damaged rudder stock gland as the waves battered the aft section of the ship.

On 13 February, after number one port and starboard cargo tanks were full of sea water, the ship refloated.

On 18 February, salvage experts from Svitzer Salvage arrived on the Cocos Islands and prepared the ship to be towed.

At 1530 on 28 February, *Breakthrough* departed the Cocos Islands under tow by *Svitzer Celine*, bound for Singapore for permanent repairs.

2 ANALYSIS

2.1 Evidence

On 14 February 2008, two investigators from the Australian Transport Safety Bureau (ATSB) interviewed the Australian Federal Police (AFP) officers on West Island. Copies of documents and photographs relevant to the ship were taken.

On 15 February, the investigators attended *Breakthrough* while the ship was at anchor off Direction Island. The master and chief engineer were interviewed and relevant documents and records were obtained. Photographs were taken of the ship and its equipment and other evidence was gathered, including a copy of the navigational chart used for the voyage, copies of log books, bell books, and various procedures.

2.2 The grounding

At about 1545 on 12 February, *Breakthrough* grounded off the western tip of Direction Island, in the Cocos Island group, when its anchors dragged in strong winds and heavy seas. The ship had anchored off Direction Island on 11 February after drifting in the Indian Ocean for about 21 days following difficulties encountered running the ship's main engine using intermediate fuel oil (IFO).

The area available for *Breakthrough* to anchor was very small and the ship had anchored about 4 cables[16] from Direction Island. At the time, this anchorage was suitable because it was the only area available to provide protection from the predominantly south-easterly winds. However, on 12 February, when the wind swung around to the west-south-west and increased in strength, the ship was anchored off a lee shore in the westerly winds and it was driven towards the shore by the wind.

When the weather changed, there were few options available to the master. He could have weighed anchor and put to sea to either slow steam or drift offshore until the weather abated but, after spending 21 days adrift, it is likely that he was reluctant to take the ship away from its anchorage. He could not veer more anchor cable to prevent the anchor from dragging because the extra cable would have allowed the ship to drift closer to the shore.

Therefore, the master's only reasonable option, under the circumstances, was to let go another anchor and to run the ship's main engine ahead to take the load off the anchors and attempt to maintain the ship's position. This he did. However, he was concerned about the condition of the main engine and its fuel system so he only ran the main engine at slow ahead, as he had on the final stages of the voyage to the Cocos Islands. This did not provide sufficient power to prevent the anchors from dragging and consequently, the ship's stern grounded.

Given the possible consequences of the ship grounding, it would have been more prudent for the master to run the main engine harder to prevent the ship from grounding, even to the point of damaging the engine in order to save the ship.

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16 One cable equals one tenth of a nautical mile or 185.2 m.

2.3 Fuel system

On 20 January 2008, when *Breakthrough*'s main engine fuel system was changed over from MDO to IFO, the fuel unit duplex filter differential pressure began to rise as the IFO replaced the MDO in the system, suggesting to the engineers that the filter was becoming blocked.

The high filter differential pressure could have occurred because the fuel contained a high proportion of solid contaminants. It is also likely that the fuel temperature at the main engine inlet was too low, resulting in a high viscosity. A high viscosity would increase the fuel's flow resistance in system components such as valves, bends and filters, resulting in an increased differential pressure across the filter.

The ship's main engine had not been configured for using IFO before the ship departed China.

2.3.1 Use of IFO in *Breakthrough*'s main engine

One operating problem which can occur when using residual fuel in a diesel engine is that the high temperature in the cylinder can 'crack' the fuel, burning off the volatile lighter components and leaving heavy carbon deposits, or 'trumpets', around the injector nozzle holes which can lead to poor atomisation and combustion problems. Carbon trumpets usually form, break off and then reform in a cyclic manner. Nozzle cooling is used to prevent the formation of these carbon trumpets.[17]

'With smaller engines of up to 300 mm bore, it is usually sufficient to rely on the passage and recirculation of the pumped fuel to achieve the necessary cooling'[18]. So, while it is possible that some small bore diesel engines can be run without nozzle cooling, an engine should not be run without nozzle cooling unless specified by the engine manufacturer or in an emergency.

Breakthrough's main engine manual stated that injectors with nozzle cooling were required in order to run the engine using 'heavy diesel oil of high viscosity' but, at the time of the incident, *Breakthrough*'s main engine was not fitted with nozzle cooled injectors or a nozzle cooling module.

The absence of a nozzle cooling system did not affect the transfer, purification or filtration of the fuel and would not have prevented the high fuel filter differential pressure. However, *Breakthrough*'s main engine, as configured on the ship's delivery voyage, was not designed for use with IFO and the ship's owner should not have bunkered IFO without modifying the engine to use it.

2.3.2 Fuel oil heating

The IFO used in the main engine should have been injected at a viscosity of less than about 14 cSt, usually achieved for this grade of fuel by heating it to a temperature of about 120°C. The viscosity should have been regulated by the fuel unit viscometer. However, the engineers were unable to operate the viscometer effectively so they by-passed it and manually controlled the fuel oil temperature using the thermometer at the fuel unit outlet (Figure 11).

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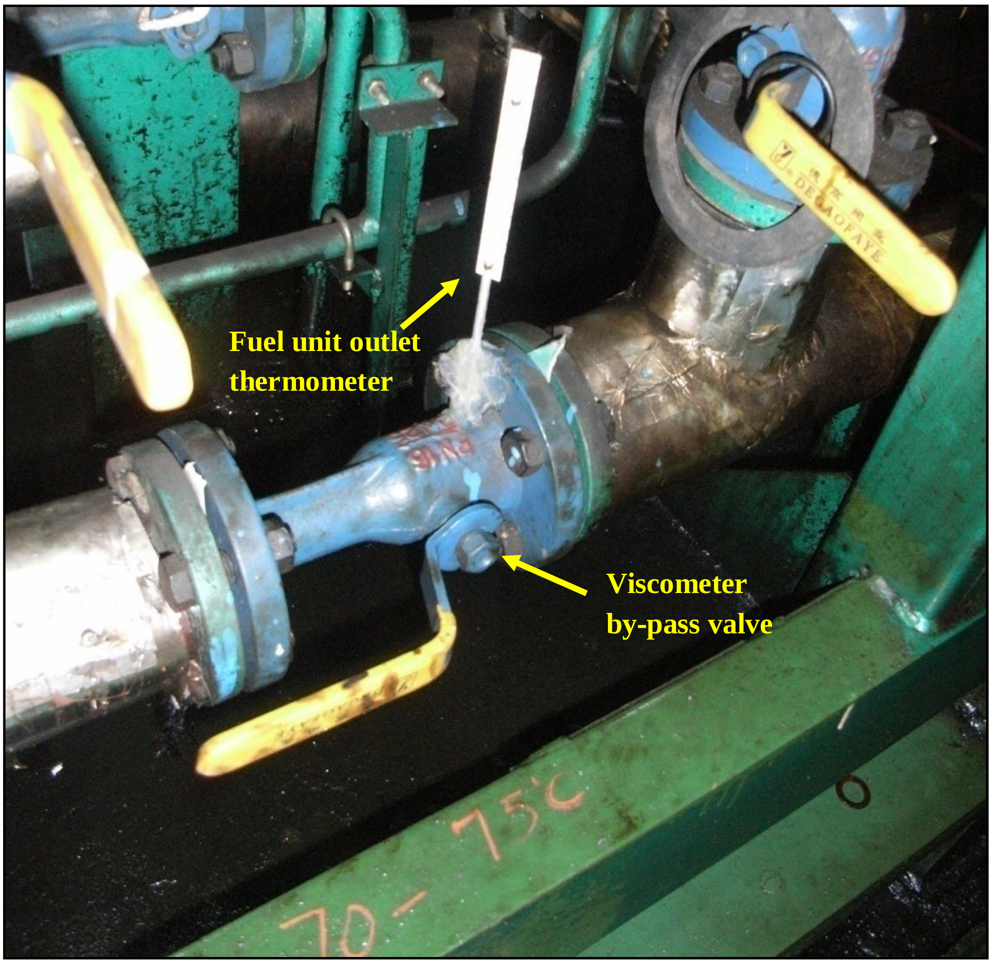
17 Clark, G.H. (1988), *Industrial and Marine Fuels Reference Book,* p22/30.

18 Woodyard D. (2003), *Pounder's Marine Diesel Engines and Gas Turbines*, 8th Edition, p 231.

The fuel unit, fuel tanks and the purifier heater all relied on steam provided by the ship's composite boiler to heat the fuel to an appropriate temperature. The chief engineer told the ATSB that the steam plant had been performing satisfactorily with the exception of some minor steam leaks and a defective steam valve, which he had replaced. However, a review of the engine room log book indicated that the boiler only produced steam while the main engine was running, using heat from the main exhaust gas uptake, indicating that the oil-fired boiler burner had not been used. Therefore, when the main engine was not running, no steam was produced, allowing the steam system to cool.

For most of the voyage from China until the fuel was changed over, the main engine was run at 500 rpm and the resultant maximum boiler pressure was logged as 4.0 bar on 11 January. Steam at 4.0 bar has a saturated steam temperature of 150°C.

Figure 11: Fuel unit viscometer bypass valve and outlet thermometer



On 14 January, when the purifier was commissioned and on 20 January, after the main engine was changed over to IFO, the steam pressure was logged as 2.5 bar (a saturated steam temperature of 139°C). Allowing for some heat loss in the pipes and heaters, this steam temperature would probably not have been sufficient to heat the fuel to 120°C, as required.

After the engineers reduced the main engine speed because of the fuel filter problems, the steam pressure dropped to about 1.0 bar (a saturated steam temperature of 120°C). While the main engine was not running at full speed, it was impossible to heat the fuel to the required 120°C.

The only occasions that the fuel temperature was recorded in the engine room log were on 22 January. At 1200, the fuel temperature was 85°C and at 1600, it was 96°C. The boiler pressure was logged as 3.0 bar and 2.5 bar respectively. The IFO fuel at 96°C would have had a viscosity of about 30 cSt. At 85°C, the viscosity of the fuel would have been about 40 cSt. A suggested temperature range of 70 to 75°C was marked adjacent to the fuel unit outlet thermometer (Figure 11) and this would have had a viscosity of nearly 60 cSt.

The evidence indicates that the fuel was not heated to the required temperature. Consequently, the increased viscosity of the low temperature IFO could have accounted for the higher differential pressure across the fuel duplex filters, suggesting to the engineers that the filters were becoming blocked almost immediately after the fuel was changed over from MDO to IFO.

The fuel unit final filter was a 4 µm duplex filter. A larger mesh size should have been used for IFO. The engineers did not change over to the 10 µm filter elements until after they had stopped trying to use IFO and were using the contaminated MDO. Had they used the 10 µm filter elements earlier, the filter differential pressure would probably not have risen as quickly.

In submission the chief engineer stated:

> Neither increase in heating temperature nor the continuous operation of the backflushing handle was able to meet the main engine demand. When the turbocharger started showing the first signs of coughing we reverted back to clean diesel oil. It was surprising to see the same filter that could not handle the F.O. 180cst allow the free flow of clean M.G.O. without first removing and cleaning the filter element.

The chief engineer’s submission also supports the likelihood that the fuel was not heated sufficiently. The turbocharger coughing or surging is a symptom of late and unstable combustion, probably as a result of the fuel atomising poorly due to its high viscosity. The filter did not require cleaning because it was not dirty. The filter's back-pressure was high because the viscosity of the fuel was too high for the filter’s mesh size.

2.3.3 Fuel oil purifier

The fuel oil service tank was filled by purifying fuel from the fuel oil settling tank to remove water and solid contaminants. Centrifugal purifiers can remove large quantities of water without losing their filtration efficiency and, ‘correctly operated, they can remove solid particles down to 3 – 5 µm, which places them in the fine filter category’[19]. This level of performance should have been sufficient to remove most of the solid particles from the fuel, thereby reducing the frequency that the fuel unit’s filters would need cleaning.

The Industrial and Marine Fuels Reference Book states[20]:

> One of the main causes of poor combustion, deposit and corrosion problems when

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[19] Clark, G.H. (1988), *Industrial and Marine Fuels Reference Book,* p21/7.

[20] ibid.

burning residual fuel is inefficient operation of the centrifuge.

The use of the fuel oil purifier was recorded in the engine room log book. At 1800 on 14 January, the engineers commissioned a fuel oil purifier and began to purify IFO from the fuel oil settling tank into the fuel service tank. On 16 January, the purifier was shut down to repair a leaking sludge pipe flange and it was not restarted. It is possible that, because the fuel oil service tank was full, the engineers considered that they didn't need to run the purifier again until the main engine was changed over to IFO. On 19 January, the purifier was test run and then shut down. These were the only occasions that the purifier was recorded as being operated during the voyage.

To ensure proper purification and pre-heating of the IFO, a purifier should have been run continuously from the time that the IFO bunkers were taken, allowing the contents of the service tank to overflow back into the settling tank for re-purification. This process would have ensured that the fuel oil service tank's contents were as hot and clean as possible.

The fuel inlet temperature to the purifier should have been about 98°C and the gravity disc and backpressure set for efficient purification. On 26 January, the shipbroker's engineer in China urged *Breakthrough*'s chief engineer to use the purifier properly to ensure the oil filter did not become clogged and that the purifier inlet temperature should be maintained at about 98°C. Given that the steam pressure was recorded as low, it is likely that the purifier fuel inlet temperature was low. The ATSB was not advised of the size of the gravity disc used. However, it could not have been too large, otherwise fuel would have carried over with the water discharge although it is possible that it was too small, resulting in inefficient purification.

The purifier had not been commissioned and run before the ship departed China. Furthermore, it was not run constantly after it had been commissioned to clean the fuel in the settling tank. It is possible that *Breakthrough*'s fuel oil purifier was not run efficiently to remove the water or solid contaminant particles from the fuel, leaving the fuel in the service tank 'dirty'.

2.3.4 Fuel tanks

When the crew arrived in China to take delivery of the ship, none of the ship's fuel oil bunker, settling and service tanks, had been emptied and cleaned. The ship's main engine had not been run on IFO for most of the ship's life so any fuel that remained in the tanks had been there for a couple of years.

The fuel oil service tank should have been emptied and cleaned to ensure that it was ready for service before any fuel was purified into it. However, the engineers did not clean the fuel oil settling or service tanks until 25 January, after they had encountered problems using the fuel.

On 27 December 2007, *Breakthrough* bunkered about 100 tonnes of IFO into the engine room IFO bunker tanks and about 300 tonnes into the number three starboard cargo oil tank. It is possible that the fuel that was bunkered in China contained a high proportion of solid contaminants and that these solids were not removed from the fuel during purification.

2.4 Decision making

2.4.1 Changing over fuel

The engineers had initially expected to run the main engine for the delivery voyage using MDO rather than IFO. Consequently, they did not take the time to trace pipes and learn the ship's fuel systems and they did not appropriately prepare the fuel unit or the purifiers. Therefore, when the ship's owner insisted that they take on IFO bunkers to reduce the fuel cost for the delivery voyage, they had not made the necessary preparations for its use. Furthermore, when they had been told that they would be completing part of the voyage using IFO, they did not prepare the systems or check their operation until after the voyage was well underway.

The chief engineer delayed making the decision to change over the main engine from MDO to IFO until as late as possible and, when the time came to change over the fuel, he remarked that 'D-Day has come'.

It would have been prudent for *Breakthrough*'s engineers to have commissioned these systems immediately after they were told that they would be bunkering IFO for the voyage, in December 2007. Had the systems been tested before the ship sailed from Zhoushan, it may have been possible to correct any problems and make the systems reliable before starting the voyage. The engineers also did not take action to commission and test the fuel system or purifiers until the ship was in the Indian Ocean. They had 8 days - up until arriving at Sunda Strait - when they could have, and should have, tested the systems.

By not appropriately testing the ship's fuel systems, the ship's engineers lost the opportunity to take action to correct any problems with the system. The decision to not test the systems necessary for using IFO and to wait until the latest possible time to change over to IFO, suggests that the ship's senior officers did not adequately manage the risks associated with their decisions.

2.4.2 Altering the voyage plan

The master's original passage plan to keep *Breakthrough* close to land as it steamed around the edge of the Indian Ocean was sound given the crew's unfamiliarity with the ship and the condition of the ship's equipment.

However, on 15 January, he changed his plan and decided to take the ship directly across the Indian Ocean to Africa. As the voyage had progressed, the master's confidence with the ship's reliability had increased because it had been performing satisfactorily. Moreover, the crew were eager to get home because they had been away for much longer than they had originally expected and the change in plans meant that the ship would have to travel about 1,000 miles less, making the voyage about 4 days shorter.

Regardless of the reasons which led to the change of plans, the master's decision was based on incomplete information. Very little risk assessment was performed and the 'rush to get there' had swayed the, ultimately flawed, decision making process. The master may have been confident in the ship's performance but many of the systems that would need to be used in the Indian Ocean, particularly running the main engine on IFO, still had not been tested and proven to be reliable. Furthermore, the master did not receive weather forecasts on board the ship and chose not to obtain weather information using HF radio from the nearest coastal radio stations. Consequently, he did not have the information necessary to plan his route appropriately to avoid adverse weather.

The master's decision to change from a sound and cautious passage plan was based on incomplete information and exposed the crew to unnecessary risk.

2.4.3 Drifting

On 27 January, after the engineers had been unsuccessful in running the main engine on IFO and most of the remaining MDO had been contaminated with IFO, the master needed to get supplies of clean MDO. At the time, the ship was 420 miles from the Cocos Islands and about 950 miles from the Sunda Strait.

The chief engineer checked all of the ship's fuel tanks to determine how much fuel remained on board. There was 79 m^3 of contaminated MDO, about 307 m^3 of IFO and a total of about 33 m^3 of clean MDO on board, stored in four tanks in the engine room, including 5 m^3 in the generator service tank.

The ship's normal daily fuel consumption was about 10.4 tonnes, or 12 m^3, per day and the ship was able to average about 10 knots with that fuel consumption.

It would have taken about 95 hours of steaming for the ship to reach the Sunda Strait, using about 47.5 m^3 of MDO, more clean MDO than was available. The ship could have used the dirty, contaminated MDO and, even though the filters would have needed regular, frequent cleaning, the ship could have safely sailed to Jakarta via the Sunda Strait with sufficient clean MDO in reserve.

It would have taken about 42 hours of steaming to reach Cocos Island, using about 21 m^3 of MDO, which would still leave a supply of clean MDO for the generator. Even if enough fuel was not available on the Cocos Islands, the ship's crew would have been in a safe place and would be able resupply and to clean and recommission the fuel system to either continue the voyage to Nigeria using IFO, or return the ship to Indonesia to take on more clean MDO bunkers. Alternatively, additional fuel could have been ordered for delivery to the Cocos Islands.

Either way, the ship should have steamed towards a port of refuge rather than drifting in the Indian Ocean for a further 2 weeks. Each day that the ship drifted, its generators used another tonne of clean MDO, reducing the ship's range using clean MDO and the crew consumed more of the dwindling supplies of food and water.

The decision to drift rather than using the available fuel to reach the closest port exposed the crew to unnecessary hardship and risk. *Breakthrough*'s crew almost ran out of food and clean drinking water before the decision was made to steam towards the closest port.

2.5 Human factors

2.5.1 Knowledge and experience

The ship's manuals and diagrams were written in Chinese and not English, the common language of the crew. This made the task of 'learning the ship' more difficult for the crew but not impossible. The equipment and systems on board

Breakthrough were very similar to those found on most ships. By identifying items of equipment and following the pipes connecting them, the engineers would have been able to develop a sound understanding of the ship's systems. Similarly, there was sufficient opportunity to learn how to operate all of the equipment while the Chinese shipbroker was available to assist them with translating the Chinese signs and instructions into English.

The number of engineering issues which were present on board *Breakthrough* strongly suggests that the engineers possibly lacked the necessary knowledge and experience to undertake the voyage. The oily water separator was never tested or commissioned, the air conditioning plant did not work and was never commissioned. There were also a number of electrical problems with generator control and the steering gear power supply. Furthermore, after the emergency switchboard was damaged, before the voyage had even started, it was not repaired.

Most importantly, the steam system and the main engine IFO fuel system were not operated correctly. The fact that the boiler was not effectively utilised to provide sufficient steam to heat the fuel suggests that the chief engineer did not understand the importance of fuel temperature and viscosity or the need to run the boiler burner.

The chief engineer had no previous experience as a chief engineer and his most recent experience had been in the offshore industry, on board vessels that did not have a steam system and only used MDO. This experience did not adequately prepare him for his role as chief engineer on board an unfamiliar ship using IFO in its main engine.

During attempts to resolve the fuel system problems, the clean MDO in the number five port cargo oil tank was contaminated with IFO when the cargo oil system was not operated correctly. While the valves were labelled in Chinese, the master and engineers had not familiarised themselves with the cargo oil piping and transfer system and were not able to operate the system correctly.

The master, chief engineer, second engineer and the electrician had been in China since 21 September 2007 until the ship departed from China on 7 January 2008, a period of over 3 months, and during that period they had spent significant amounts of time on board the ship looking for defects and familiarising themselves with it. This should have provided them with sufficient time to adequately learn the ship's systems and to test all of the equipment necessary for the delivery voyage, particularly while the shipbroker and his staff were still close by.

The operation of the ship's systems and the decisions made by the ship's senior officers suggests that they did not have sufficient knowledge and experience to safely undertake *Breakthrough*'s delivery voyage and that they did not effectively use the time spent in China, standing by the ship, to acquire the necessary knowledge.

2.6 Ship management

2.6.1 International Safety Management Code

The International Safety Management Code (ISM Code) was developed by the International Maritime Organization (IMO) to provide a standard for the safe management and operation of ships. Under the IMO's Safety of Life at Sea Convention (SOLAS[21]), the ISM Code has applied to all tankers, of 500 gross tonnage and upwards, since 1 July 1998.

The ISM Code requires all ships to have a safety management system (SMS). It is to be implemented on board and details how a company will provide for safe practices in ship operation and a safe working environment, establish safeguards against all identified risks and continuously improve safety management skills of personnel ashore and aboard ships, including preparing for emergencies related both to safety and environmental protection[22]. The 'ISM Code Company' is either the ship's owner or a manager that has accepted the responsibility for the safe operation of the ship[23].

Each company must have a Designated Person Ashore (DPA) who will ensure the safe operation of each ship. This person is to provide a link between the company and the ship's crew and to ensure that adequate resources and shore based support are applied for the safe operation of the company's ships[24]. Each company should also ensure that their ships are manned with appropriately qualified crews, that masters are fully conversant with the company's SMS and that each ship's master is given all necessary support to fulfil their duties[25].

Under the ISM Code, each company is issued with a Document of Compliance (DOC) by the administration of the flag State as evidence that the Company is capable of complying with the requirements of the ISM Code. Each ship is issued with a Safety Management Certificate (SMC) once the administration has verified that the Company and its shipboard management operate in accordance with the approved SMS[26].

2.6.2 Ship's certification and safety management

Breakthrough's certificate of registry was authorised by the general manager of Mark Ship Management and Consultant Co. (Mark Ship Management) in China on behalf of the Republic of Sierra Leone on 24 December 2007. Mark Ship Management was also the DOC and SMC "Company" for *Breakthrough* and both of these certificates were issued by the marine superintendent of Mark Ship Management, under the business name New United (Int'l) Marine Service, on behalf of the Republic of Sierra Leone. Therefore, Mark Ship Management issued statutory ISM Code certificates to itself, on behalf of the Republic of Sierra Leone, so that the ship had the necessary certificates to undertake its delivery voyage.

However, Mark Ship Management had no role in operating or managing *Breakthrough*. The ship was owned by Jevkon Oil and Gas, which operated a fleet of small product tankers on the Nigerian coast which were managed by Capricorn

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21 SOLAS, Chapter IX 'Management for the Safe Operation of Ships', Regulation 2.

22 International Safety Management Code (ISM Code) Section 1.2.2.

23 ibid. Section 1.1.2.

24 ibid. Section 4.

25 ibid. Section 6.1.

26 ibid. Section 13.

Maritime, a subsidiary of Jevkon Oil and Gas. Therefore, under the ISM Code, Mark Ship Management could not have been the ship's DOC Company.

In addition, the safety management system provided to *Breakthrough* was neither the ship's owners nor the ship's managers. It did not contain any useful guidance or procedures for the ship's crew with regard to operating the ship or emergency preparedness, as required under the ISM Code. The ship's SMS was a generic document, written in both Chinese and English, which had been provided to the ship on 15 December 2007 by Mark Ship Management.

The DPA was Mark Ship Management's marine superintendent. However, when the ship began experiencing problems, the master contacted the ship's owner in Nigeria. When he did not get the assistance he needed from the owner, he contacted the shipbroker in China for help. The ship's master did not contact the DPA at any time.

Breakthrough's SMS was inadequate and the ship's certification was issued solely for the purpose of allowing the ship to sail on an international voyage, and this strongly suggests that the ship's owner had little regard to effectively implementing the principles of the ISM Code. Had Jevkon Oil and Gas implemented an effective SMS on board *Breakthrough*, the ship's equipment may have been tested and the crew familiarised with it before the ship departed Zhoushan, minimising the risk of an incident.

2.6.3 Management support

When the owner purchased *Breakthrough* through a shipbroker in China, he told the master and chief engineer that they were delivering a 'near new' ship from China to Nigeria. It is usual practice for a ship to be inspected by masters, chief engineers and superintendents before it is purchased to verify the suitability of the ship for its intended role, and that it is in good condition and has all of the necessary equipment on board.

Breakthrough's drawings, manuals and documentation were not in English and, as such, were not of much use to the ship's crew. Many of the critical systems were not operational and were not tested. The ship also did not have a complete inventory of spare parts and special tools. Despite the chief engineer highlighting these issues to the ship's owner when he came to China to finalise the purchase, little action was taken to address them.

The chief engineer notified the owner that the main engine needed to be modified to use IFO but the main engine modifications were not made. Yet the owner still ordered IFO for the voyage. It appeared that the owner was determined to use IFO in the main engine for the delivery voyage and did not support his senior officers when they explained the situation to him.

After the MDO was contaminated with IFO and the ship began to drift in the Indian Ocean, the master requested the ship's owner to arrange for a supply of clean MDO to be delivered to them at sea. The ship's owner told the master that he was organising the fuel and that he was arranging payment for it when, in fact, he had taken no action. The ship continued to drift, while the crew waited for the owner to organise the delivery of clean fuel. When the owner did not provide them with the support that was expected, the crew became increasingly desperate.

Of the organisations contacted by the ship's master, only the Chinese shipbroker provided any level of support. However, he could not comply with the master's requests for fuel without the endorsement of the ship's owner, an endorsement which was not forthcoming.

Under the ISM Code, ship owners must ensure that each ship's master is given all necessary support to fulfil their duties. Clearly, Jevkon Oil and Gas did not provide the necessary support, either before the commencement of the delivery voyage or after the ship began having difficulties using the IFO in the main engine and began drifting in the Indian Ocean.

3 FINDINGS

3.1 Context

At 1545 on 12 February 2008, *Breakthrough* grounded off the northern tip of Direction Island, in the Cocos (Keeling) Islands, when the ship's anchor dragged in heavy weather. The ship had anchored off the Cocos Islands after drifting in the Indian Ocean for about 3 weeks.

From the evidence available, the following findings are made with respect to the grounding of *Breakthrough* in the Cocos Islands and should not be read as apportioning blame or liability to any particular organisation or individual.

3.2 Contributing safety factors

- At 1200 on 12 February, *Breakthrough*'s anchor began to drag as a storm front passed across the Cocos Islands with strong westerly winds and heavy seas. The master let go a second anchor and ran the main engine but this did not prevent the ship from grounding.
- *Breakthrough* anchored off the Cocos Islands after it had made little progress on a voyage across the Indian Ocean and had drifted for about 3 weeks because of fuel system problems.
- During attempts to resolve the ship's fuel system problems, the clean diesel fuel in the number five port cargo oil tank was contaminated with intermediate fuel oil.
- When *Breakthrough*'s main engine fuel system was changed over from marine diesel oil to intermediate fuel oil, the fuel unit duplex filter differential pressure began to rise as the intermediate fuel oil replaced the marine diesel oil in the system, suggesting to the engineers that the filter was becoming blocked.
- When *Breakthrough* sailed from China, its fuel oil service tank had not been cleaned before the engineers started purifying fuel into it. It is likely that the tank was dirty and not ready for use.
- The fuel oil purifier had not been commissioned and run before the ship departed China. Furthermore, during the subsequent voyage it was not operated in a manner which would have been as effective as possible in removing the water and solid contaminant particles from the fuel which left the fuel in the intermediate fuel oil service tank 'dirty' and unsuitable for use in the main engine.
- The steam plant was not effectively operated to provide sufficient steam for heating the intermediate fuel oil for either purification or for use in the main engine. Consequently, the main engine fuel inlet temperature remained too low, resulting in a high fuel viscosity and a high differential pressure across the fuel filters.
- The ship's engineers did not make preparations for using the intermediate fuel oil until the ship had used most of the marine diesel oil on board. Consequently, the systems necessary for using intermediate fuel oil had not been tested while the engineers were still able to obtain ready assistance from ashore to repair

them. The decision to not test the systems and to wait until the latest possible time to change over to intermediate fuel oil suggests that the ship’s senior officers did not adequately manage the risks associated with these decisions.

- *Breakthrough*’s main engine was not configured on the ship's delivery voyage for use with intermediate fuel oil and the ship's owner should not have bunkered intermediate fuel oil without the appropriate modifications to the main engine.
- The master’s decision to change from a sound and cautious passage plan was based on incomplete information and exposed the crew to increased risk because many of the systems that would need to be used in the Indian Ocean, particularly running the main engine on intermediate fuel oil, had not been tested and proven to be reliable.
- The decision to drift in the Indian Ocean rather than using the available fuel to reach the nearest port exposed the crew to unnecessary hardship and risk. *Breakthrough*’s crew almost ran out of food and clean drinking water before the decision was made to steam towards the closest port and the ship almost exhausted its supply of clean fuel bunkers.
- The International Safety Management (ISM) Code requires ship owners to ensure that each ship’s master is given all necessary support to fulfil their duties. However, Jevkon Oil and Gas did not provide the necessary support either before the commencement of the delivery voyage or after the ship’s crew began having difficulties with the main engine’s fuel and started drifting in the Indian Ocean. *[Minor safety issue]*
- The ship’s safety management system was inadequate. Had Jevkon Oil and Gas implemented an effective safety management system on board *Breakthrough*, the risk of an incident such as the one that occurred on the delivery voyage would have been reduced. *[Minor safety issue]*
- The ship’s certification was issued by a management company to itself on behalf of the Republic of Sierra Leone, solely for the purpose of allowing the ship to sail on an international voyage and it did not represent the ship’s actual management or that any effective inspections of the ship or audits of the ship's safety management system had taken place. *[Significant safety issue]*
- The operation of the ship’s systems and the decisions made by the ship’s senior officers suggests that they did not have sufficient relevant knowledge and experience to safely undertake *Breakthrough*’s delivery voyage and they did not effectively use the time spent in China, standing by the ship, to acquire the necessary knowledge. *[Significant safety issue]*

4 SAFETY ACTION

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 organisation(s). In addressing those issues, the ATSB prefers to encourage relevant organisation(s) to proactively initiate safety action, rather than to issue formal safety recommendations or safety advisory notices.

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

4.1 Jevkon Oil and Gas

4.1.1 Management support

Minor safety issue

The International Safety Management (ISM) Code requires ship owners to ensure that each ship's master is given all necessary support to fulfil their duties. However, Jevkon Oil and Gas did not provide the necessary support either before the commencement of the delivery voyage or after the ship's crew began having difficulties using the intermediate fuel oil in the main engine and started drifting in the Indian Ocean.

ATSB safety advisory notice MO-2008-003-SAN-047

The ATSB advises that Jevkon Oil and Gas should consider the implications of this safety issue and take action where considered appropriate.

4.1.2 Safety management system

Minor safety issue

The ship's safety management system was inadequate. Had Jevkon Oil and Gas implemented an effective safety management system on board *Breakthrough*, the risk of an incident such as the one that occurred on the delivery voyage would have been reduced.

ATSB safety advisory notice MO-2008-003-SAN-048

The ATSB advises that Jevkon Oil and Gas should consider the implications of this safety issue and take action where considered appropriate.

4.2 Sierra Leone International Ship Registry

4.2.1 Statutory certificates

Significant safety issue

The ship's certification was issued by a management company to itself on behalf of the Republic of Sierra Leone, solely with the purpose of allowing the ship to sail on an international voyage and did not represent the ship's actual management or that any effective inspections of the ship or audits of the ship's safety management system had taken place.

ATSB safety recommendation MO-2008-003-SR-049

The ATSB recommends that the Sierra Leone International Ship Registry should address this safety issue.

4.3 Ship owners, operators and masters

4.3.1 Knowledge and experience

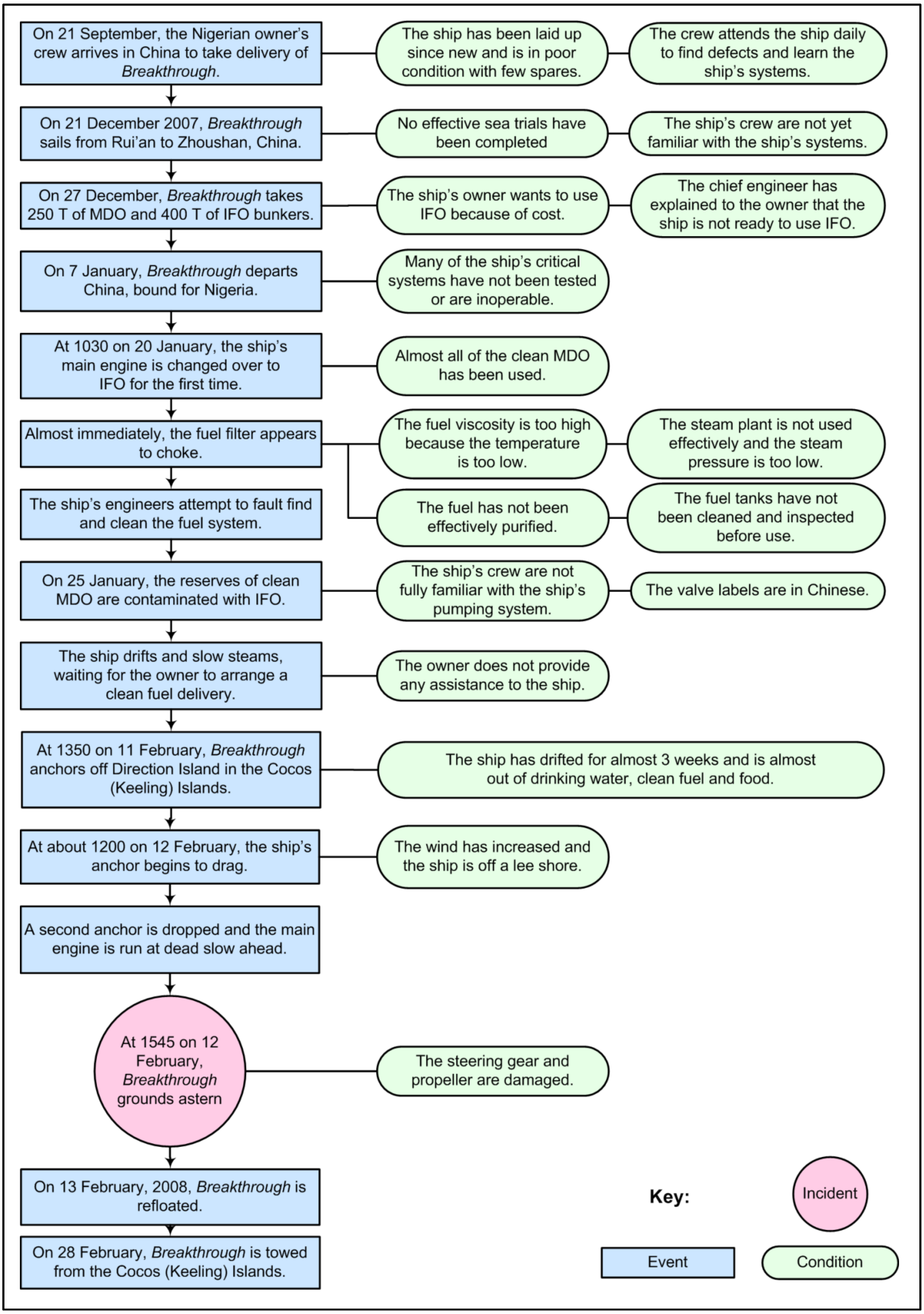
Significant safety issue

The operation of the ship's systems and the decisions made by the ship's senior officers suggests that they did not have sufficient relevant knowledge and experience to safely undertake *Breakthrough*'s delivery voyage and they did not effectively use the time spent in China, standing by the ship, to acquire the necessary knowledge.

ATSB safety advisory notice MO-2008-003-SAN-050

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

APPENDIX A: EVENTS AND CONDITIONS CHART



APPENDIX B: SHIP INFORMATION

Breakthrough

IMO Number	9095723
Call sign	VJFY
Flag	Sierra Leone
Port of Registry	Freetown
Classification society	Nil
Ship Type	Products tanker
Builder	Rui'an Jiangnan Shiprepair and Shipbuilding Company
Year built	2006
Owners	Jevkon Oil & Gas Ltd, Nigeria
Ship managers	Capricorn Maritime Ltd, Nigeria
Gross tonnage	4,393
Net tonnage	2,460
Deadweight (summer)	7,032 tonnes
Summer draught	6.9 m
Length overall	117.4 m
Length between perpendiculars	109 m
Moulded breadth	16.5 m
Moulded depth	8.3 m
Engine	Guangzhou 8320 ZCD-6
Total power	2,060 kW
Speed	10 knots
Crew	15

APPENDIX C: SOURCES AND SUBMISSIONS

Sources of information

Australia Federal Police

Australian Maritime Safety Authority (AMSA)

Bureau of Meteorology (BoM)

Breakthrough's master and crew

Patrick's Stevedores (Cocos Island)

References

Clark, G.H. (1988), *Industrial and Marine Fuels Reference Book,* p21/7.

International Safety Management Code (ISM Code).

International Convention for the Safety of Life at Sea (SOLAS), 1974, as amended.

Woodyard D. (2003), *Pounder's Marine Diesel Engines and Gas Turbines,* 8th Edition.

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.

The final draft of this report was sent to *Breakthrough'*s master and chief engineer, the Sierra Leone Maritime Administration, the Australian Maritime Safety Authority (AMSA), the Australian Federal Police (AFP) on Cocos Island, Patrick's Stevedores (Cocos Island), Jevkon Oil and Gas and the Zhoushan Fusan International Marine Agency.

Submissions were received from *Breakthrough'*s chief engineer, Patrick's Stevedores (Cocos Island), AMSA and the Zhoushan Fusan International Marine Agency. The submissions have been included and/or the text of the report was amended where appropriate.

Independent investigation into the disablement and subsequent grounding of the Sierra Leone registered products tanker *Breakthrough* at the Cocos (Keeling) Islands, on 12 February 2008.