



Danish Maritime Accident
Investigation Board

MARINE ACCIDENT REPORT

June 2015



PARIDA
Fire on 7 October 2014

The Danish Maritime Accident Investigation Board
Carl Jacobsens Vej 29
DK-2500 Valby
Denmark

Tel. +45 23 34 23 01
E-mail: dmaib@dmaib.dk
Website: www.dmaib.com

Outside office hours, the Danish Maritime Accident Investigation Board can be reached on +45 23 34 23 01.

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Front page: PARIDA Source: DMAIB

The marine accident report is available from the webpage of the Danish Maritime Accident Investigation Board www.dmaib.com.

The Danish Maritime Accident Investigation Board

The Danish Maritime Accident Investigation Board is an independent unit under the Ministry of Business and Growth that carries out investigations as an impartial unit which is, organizationally and legally, independent of other parties. The board investigates maritime accidents and occupational accidents on Danish and Greenland merchant and fishing ships as well as accidents on foreign merchant ships in Danish and Greenland waters.

The Danish Maritime Accident Investigation Board investigates about 140 accidents annually. In case of very serious accidents, such as deaths and losses, or in case of other special circumstances, either a marine accident report or a summary report is published depending on the extent and complexity of the events.

The investigations

The investigations are carried out separate from the criminal investigation without having used legal evidence procedures and with no other basic aim than learning about accidents with the purpose of preventing future accidents. Consequently, any use of this report for other purposes may lead to erroneous or misleading interpretations.

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1. SUMMARY

On 7 October 2014, there was a fire on board the Danish flagged ro-ro cargo ship PARIDA while underway from Scrabster, United Kingdom, to Antwerp, Belgium, loaded with nuclear waste material. The fire indirectly immobilized the main engine, which caused the ship to drift in the direction of a nearby oil-field installation, resulting in the risk of an allision.

The Danish Maritime Accident Investigation Board (DMAIB) has in the investigation focused on a number of topics in relation to the fire. Among these are the properties of on-board systems and their functioning during normal operating conditions and their functioning during an emergency situation where the design is challenged by unintended and unforeseen conditions. Some of the factors preventing the unfolding of the full potential of the emergency are addressed.

It is concluded that the interrelation between the accidental events on board and interactions with the external environment created a propagating effect where a malfunctioning pressure gauge caused the evacuation of an oil-field installation. The investigation establishes that the nature of the cargo carried on board had no particular significance during the emergency situation.

2. FACTUAL INFORMATION

2.1 Photo of the ship



Figure 1: PARIDA

Source: Jens Smit/Retrieved from www.shipspotting.com

2.2 Ship particulars

Name of vessel:	PARIDA
Type of vessel:	Ro-ro cargo ship
Nationality/flag:	Denmark
Port of registry:	Korsør
IMO number:	9159933
Call sign:	OWMG2
DOC company:	Harren & Partner Ship Management
IMO company no. (DOC):	5271403
Year built:	1999
Shipyard/yard number:	Turkish Shipbuilding Industry Inc. Pendik Shipyard/021
Classification society:	DNV-GL
Length overall:	100.90 m
Breadth overall:	18.70 m
Gross tonnage:	5,801
Deadweight:	5,850 t
Draught max.:	6.933 m
Engine rating:	4,500 kW
Service speed:	15.0 knots

Hull material:	Steel
Hull design:	Single hull

2.3 Voyage particulars

Port of departure:	Scrabster, United Kingdom
Port of call:	Antwerp, Belgium
Type of voyage:	Merchant shipping, international
Cargo information:	IMO Class 7, UN 2916, (2 x 3870 kg radioactive material)
Manning:	15
Pilot on board:	No
Number of passengers:	0

2.4 Weather data

Wind – direction and speed:	E – 21 m/s
Wave height:	3-4 m
Visibility:	5 nm
Light/dark:	Daylight
Current:	NNW – 1.0 knots

2.5 Marine casualty or incident information

Type of marine casualty/incident:	Fire
IMO classification:	Serious
Date, time:	7 October 2014 at 1810 LMT
Location:	North Sea – East coast of Scotland
Position:	58°15.6' N – 002°22.3' W
Ship's operation, voyage segment:	In transit
Place on board:	Main engine funnel casing
Human factor data:	Yes
Consequences:	The thermal heat-oil system and electrical cables inside the casing were damaged. The ship lost propulsion power and was adrift.

2.6 Shore authority involvement and emergency response

Involved parties:	MRCC Shetland, MRCC Aberdeen, HM Coastguard Duty Area Officer, Duty National Search and Rescue Officer, Police Scotland, MCA Counter Pollution and Salvage Officer, Secretary of State's representative.
Resources used:	RAF SAR helicopter R 137 HM Coastguard rescue helicopter R 102
Speed of response:	00:27:01 hours (R 137) 00:43:14 hours (R 102)
Actions taken:	BEATRICE ALPHA installation personnel evacuated by two rescue helicopters.
Results achieved:	52 persons from BEATRICE ALPHA installation evacuated to Lossiemouth Royal Air Force Station.

2.7 The key personnel on board during the accident

Master:	61 years old. Had been at sea for 36 years and had been with the company for the last four years. Had served on board
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Chief officer:	PARIDA for two months. 38 years old. Had been at sea for eight years and had been with the company for the last six years. Had served on board PARIDA for one year.
Chief engineer:	48 years old. Had been at sea for 25 years and had been with the company for the last three years. Had served on board PARIDA for two years.

2.8 Scene of the accident

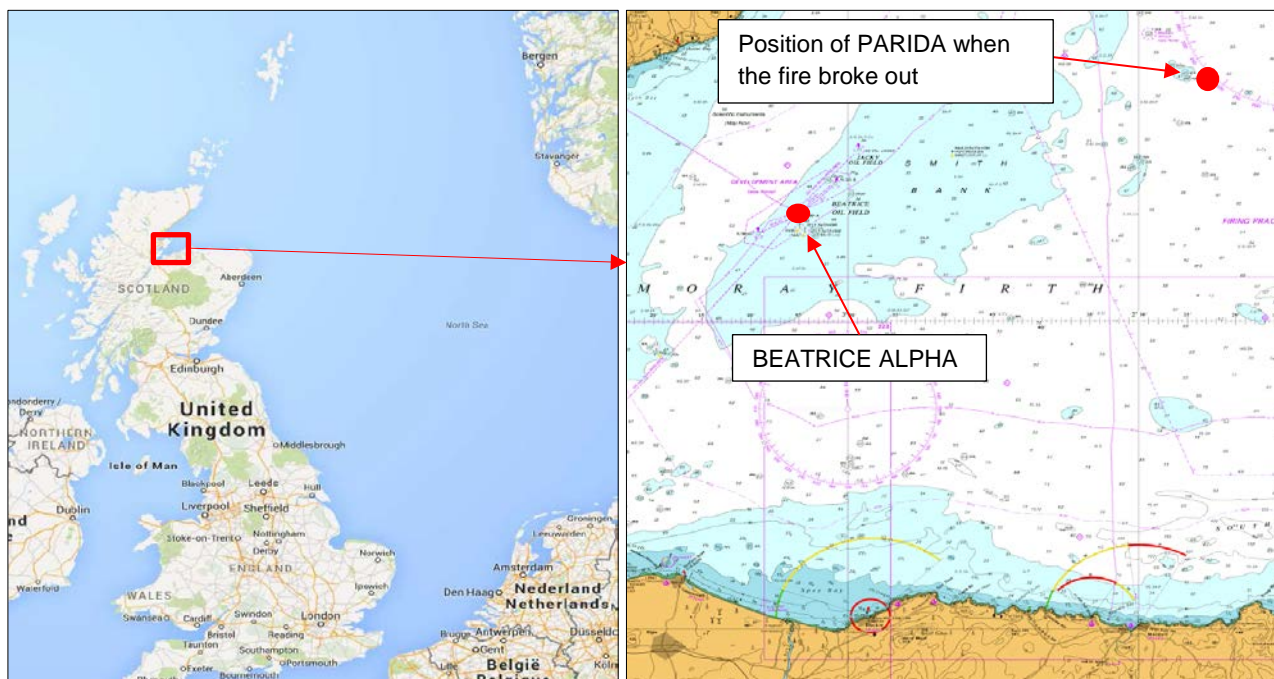


Figure 2: Scene of the accident. Moray Firth, United Kingdom

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3. NARRATIVE

3.1 Background

At the time of the accident, PARIDA was a Danish flagged ro-ro cargo ship. The ship was registered in Denmark (DIS) in February 2013 on a bareboat charter limited to two years. The charterer was the Danish company P. Jørgensen & Co. ApS, which operated the ship, while the safety- and technical management was undertaken by Harren & Partner Ship Management GmbH & Co. KG in Germany. PARIDA was erased from DIS on 6 January 2015, and is currently flying the Antigua & Barbuda flag.

PARIDA was certified to carry irradiated nuclear fuel (INF) category 1 cargo and was engaged in regular trade between Scrabster, United Kingdom, and Antwerp, Belgium. It transported radioactive material in connection with the decommissioning of a nuclear facility in the United Kingdom. The ship called at other ports occasionally and the last port of call, prior to calling Scrabster on the day before the fire, was Vlissingen in the Netherlands.

At the time of the accident, PARIDA held valid certificates issued by the classification society and by the flag state, which meant that the ship had been inspected regularly and found in a good condition. During the period that the ship had flown the Danish flag, it had been subject to port state control – *More Detailed Inspection* – twice prior to the fire on 7 October 2014: Once in Belgium in May 2013 and again in the Netherlands in March 2014. During both inspections,

deficiencies were identified. However, none were found by the DMAIB to have any direct relation to the fire.

At the time of the accident, the crew consisted of three different nationalities: Polish, Ukrainian and Danish.

All times indicated in the report are the ship's local time (UTC +2).

3.2 The sequence of events

3.2.1 *Shipboard operations prior to the accident*

On 6 October 2014, while approaching Scrabster Harbour, United Kingdom, PARIDA experienced wind forces 7-8, causing heavy rolling and pitching motions on the ship. The master informed the relevant parties ashore that he did not consider it safe to enter the port under the present weather conditions, and he therefore intended to drop the anchor and wait for the weather to improve, as predicted by the weather forecast.

At 1215, the crew members on board PARIDA dropped anchor off Scrabster. According to the weather forecast, the weather conditions would improve later in the evening. This proved to be correct and at 2120 the crew members started to heave the anchor and a pilot arrived on board to assist the ship alongside. PARIDA proceeded to the Port of Scrabster and was made all fast at 2230. Shortly after arrival, cargo on two trailers were loaded and secured.

On 7 October 2014 at 0205, the cargo operations were completed and PARIDA left Scrabster, bound for Antwerp. At the time of departure, the master considered the weather favourable with wind force 4. On the initial part of the voyage, the ship would be sheltered from the prevailing south-easterly winds.

3.2.2 *Events on the bridge and on deck*

When PARIDA passed the point of Duncansby Head and proceeded into more open seas (figure 3), wind force 6-7 were experienced and the wave height increased to 3-4 metres. The weather caused severe rolling and pitching motions and at 0600 the master decided that the ship's shaft generator was to be disengaged and two diesel generators should be engaged to secure an independent power supply during the adverse conditions. The chief engineer decided to keep a permanent watch in the engine control room, and the speed was reduced to 2-4 knots. The adverse weather conditions remained throughout the day, and the master reported this to the charterer in accordance with ship and company procedures. The master had received weather forecasts, which predicted improvements later that day and the following day.

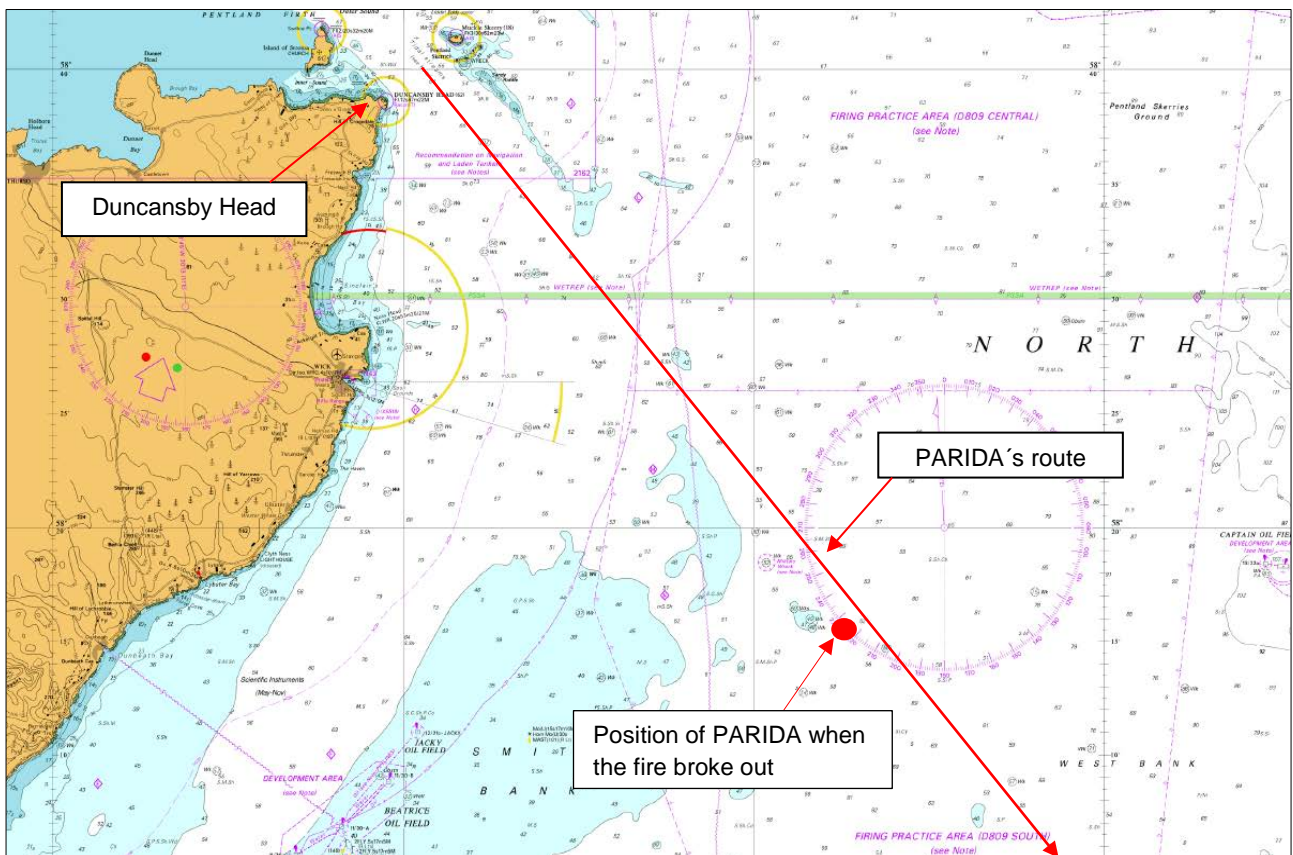


Figure 3: PARIDA's intended route. Moray Firth / North Sea, United Kingdom
Source: © Crown Copyright and/or database rights. Reproduced by permission of the Controller of Her Majesty's Stationery Office and the UK Hydrographic Office (www.ukho.gov.uk/)DMAIB

At 1800, the chief officer, the duty watchman and the master were present on the bridge. The chief officer kept the navigation watch, and the duty watchman was hand steering the ship, while the master attended to administrative work at the bridge computer.

Soon after, the chief officer observed, through the rear windows of the bridge, flames from the ship's funnel casing (figure 4). At the same time, the supercargo entered the bridge informing the master about a similar observation of fire in the funnel. Immediately after, the chief engineer also entered the bridge to discuss some administrative matters with the master. The chief engineer immediately understood the seriousness of the situation and hurried down to the engine control room.



Figure 4: Aft view from PARIDA's bridge
Source: DMAIB

The master sounded the general alarm. He remained on the bridge while the chief officer proceeded towards the muster station on the starboard side of the second accommodation deck. All additional crew members mustered at the muster station, except the chief engineer who mustered in the engine control room and the 2nd engineer who was on duty in the engine room. The chief officer briefly informed the crew members about the emergency situation. He instructed the members of the firefighting team to proceed to the firefighting equipment store on the aft ship and prepare for firefighting. To avoid exposure to the adverse weather, the firefighters went to the aft deck via the sheltered tween deck (figure 5).

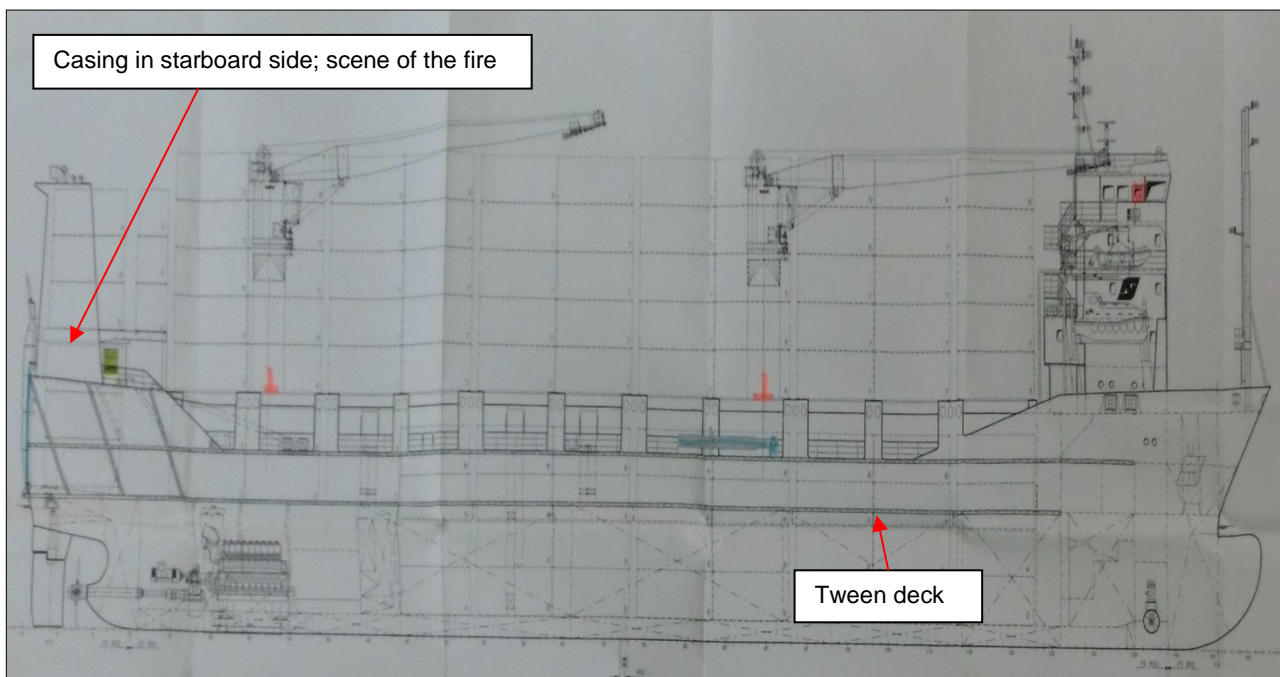


Figure 5: General arrangement of PARIDA
Source: Harren & Partner/DMAIB

At 1815, the firefighting team, led by the chief officer, started the firefighting. The chief officer had observed that the paint coating on the funnel casing exterior had begun to suffer heat damage in an area where pressurized bottles for welding were stored. The firefighting team started to cool the funnel casing with two fire hoses. Meanwhile, other firefighting team members were putting on breathing apparatus equipment in preparation for entrance into the funnel casing to fight the fire.

Simultaneously, as the firefighting efforts were initiated on deck, the funnel casing fire dampers were closed and the engine room ventilation was stopped. The master received notification from the chief engineer in the engine control room that he was going to stop the main engine. The master watched the progress of the fire in the funnel casing from the bridge rear windows and he observed that the flames had become less intense after the ventilation and the main engine had been stopped.

Over the radio, the chief officer received information from the chief engineer that the electrical power supply to the systems located inside the funnel casing had been switched off as the fire was suspected to involve the electrical installations. The chief officer observed that the fire was becoming less intense and he assessed that it was safe for the firefighting team to open the door to the funnel casing and use water to fight the fire.

Inside the funnel casing, the firefighters found themselves in dense smoke, and they observed that the fire was still burning. The two fire hoses were brought inside the funnel casing and used for the final extinction of the fire. At 1835, the fire was extinguished and the firefighters withdrew from the fire scene and closed the door to the funnel casing. Ten minutes later, the door to the funnel was opened again and firefighters inspected the scene of the fire. There were no flames but a lot of smoke. The funnel casing was then ventilated by means of the draught caused by the wind which had increased to force 9.

On the bridge, the master used the ship's satellite telephone to call the company's designated person ashore to report the fire on board. The master was informed about the company's intentions to gather the emergency management team to support the master.

3.2.3 Events in the engine room

The 2nd engineer was on watch in the engine control room, which had been manned throughout the day due to the adverse weather conditions.

Shortly after 1800, he received an alarm on the engine control room warning panel indicating that the thermal heat-oil plant had failed. The alarm was immediately followed by more alarms indicating: fire in the thermal oil exhaust gas boiler, low flow in the thermal oil system and main engine auto slowdown reducing the propeller pitch to five degrees. The 2nd engineer went to the thermal heat-oil plant control cabinet in the engine room for an inspection. At the same time, he heard the general alarm, activated by the master.

While the 2nd engineer was in the engine room, the chief engineer arrived in the engine control room. The chief engineer immediately noticed the main engine slowdown alarm on the main engine control panel. The 2nd engineer came back and found the chief engineer in the engine control room. The 2nd engineer informed about the breakdown of the thermal oil plant and the chief engineer informed about the fire in the funnel.

The engineers concluded that the main engine would need to be stopped immediately. The engine room ventilation was also shut down and the chief engineer called the bridge to inform the master about the situation and that he would lose propulsion power, as the main engine needed to be stopped.

At 1813, the chief engineer took command of the main engine changing it from bridge control to engine room control and stopped it immediately after. The alarms on the engine control panels remained active after the controlled shutdown of the main engine.

The chief engineer considered the option to dump the oil from the heat-oil system expansion tank in the casing to the drain tank at the bottom of the ship, thereby removing fuel to the fire. However, operating the quick opening drain valves would also result in the opening of the system's vent valve that was located just above the expansion tank, in the area of the fire. The chief engineer was worried that, if the system was drained, a vacuum would be created by the drained oil, and flames would enter the system and create a risk of explosion inside the expansion tank. Therefore, this option was abandoned. The engineers reasoned that, since the thermal heat-oil circulation pumps had been shut down, any leakage of oil from the system was stopped.

After the engineers were told on the radio that the fire had been extinguished, the 2nd engineer proceeded to the funnel casing to inspect the damage and the condition of the thermal heat-oil plant components.

3.2.4 Efforts to restore propulsion power

At 1853, the funnel casing was free from smoke. The chief officer and the 2nd engineer entered the funnel casing together to inspect the scene of fire. Traces of burned oil were found, and a pressure gauge was lying on the floor plating underneath an open pipe end that was part of the ship's thermal oil plant's exhaust gas boiler (figure 7).

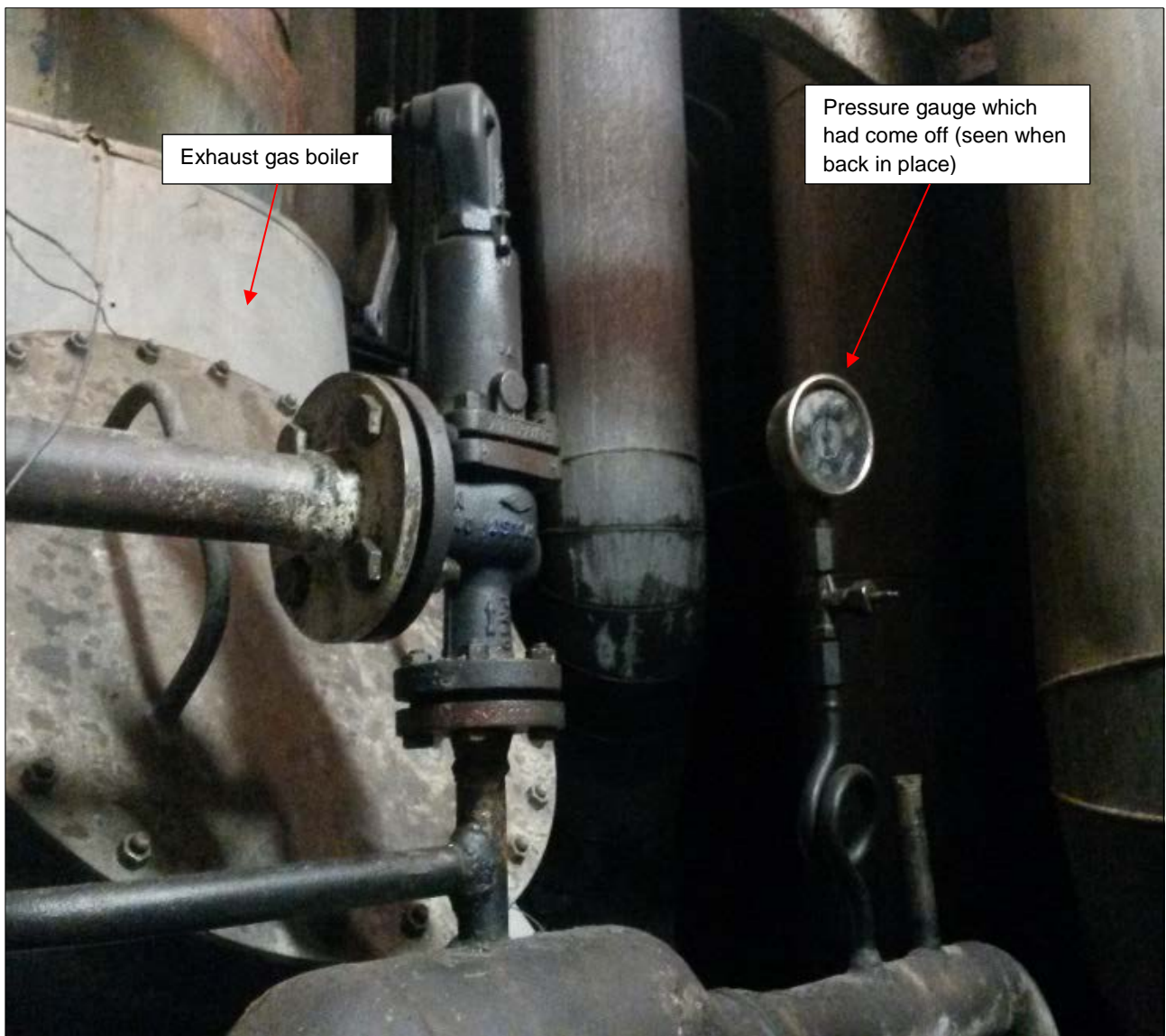


Figure 7: Unscrewed pressure gauge and exhaust gas boiler
Source: Harren & Partner/DMAIB

The pressure gauge appeared to have unscrewed from the pipe end where it had been fitted. It was assumed by the 2nd engineer that the fire had originated from the flow of pressurized thermal heat-oil from the open pipe end, ignited by the surfaces of the main engine funnel. The chief officer reported the findings to the master, on the bridge, and a crew member was put on permanent watch at the scene of the fire and fire hoses were kept readily available.

The 2nd engineer reported back to the chief engineer about the damage to the thermal heat-oil system. The damage included cabling, actuators and sensors connected to the thermal oil system. The control panel for the thermal oil system located in the engine room was inoperative.

After the fire, it was important for the master to know if it was possible to restore the propulsion power. PARIDA was drifting at a speed of 3-4 knots in the direction towards land and the BEATRICE OILFIELD installation BEATRICE ALPHA (figure 8), located approx. 20 nautical miles away. The chief engineer informed the master that the engineers would start working on the restoration of propulsion.



Figure 8: BEATRICE ALPHA installation
Source: Tigertweet/ Retrieved from www.oilrig-photos.com

The chief engineer and the 2nd engineer attempted to restore and start up the thermal heat-oil control panel. The alarms, initiated by the thermal heat-oil system, were still active and continued to give a slowdown signal to the main engine.

In the attempt to re-start the thermal heat-oil system, the pressure gauge had been refitted and fuses were replaced in the control panel. The main power to the control panel was thereby restored. However, the 24 V control power was still not present and there were no indications from the system sensors on the control panel. The engineers found it inexpedient to restart the engine due to the damaged thermal heat-oil system and the risk of starting a new fire due to the presence of oil in the funnel casing. Furthermore, restarting the engine would only provide limited propulsion as the slowdown signal was still active.

At 2038, the chief engineer informed the master that it seemed inexpedient to restore the thermal heat-oil system and re-start the main engine. However, efforts were continued by the engineers.

3.2.5 Drifting of PARIDA

Without propulsion power PARIDA was adrift, and the master calculated the ship's anticipated track under the actual weather conditions. The calculations indicated that PARIDA would pass the BEATRICE OILFIELD at a distance of 3-4 nautical miles. However, the variables of the current and wind made the calculations uncertain and there was a risk of an allision with the offshore installation BEATRICE ALPHA.

At approx. 2000, the master called the company again to update the emergency management team. They agreed to anchor PARIDA in an attempt to stop the ship from drifting. Meanwhile, the cargo and its lashings were inspected by a crew member for any effects of the heavy pitching and rolling of the ship. It was found in good order and unaffected by the impact of the weather.

Shortly after, PARIDA was contacted by Shetland Maritime Rescue Coordination Centre (MRCC) enquiring about the situation on board. Shetland MRCC had received preliminary information about the incident through a towage and salvage company that had been contacted by the company emergency management team of PARIDA for the arrangement of towing assistance. The master

informed them that an attempt at restoring the propulsion power was ongoing. Furthermore, the master informed about his intentions of anchoring to attempt to stop the ship from drifting towards the shore and the BEATRICE OILFIELD, while repairs to the thermal heat-oil system were being carried out. At this point in time, the extent of the damage was unknown and there was a continued belief on board that the propulsion could be restored.

Shetland MRCC informed the master that there was an underwater cable at the ship's position and advised him to let the ship drift another one to two nautical miles to be well clear of the cable before lowering the anchor.

At 2159, lowering of the starboard anchor was commenced. Lowering of the anchor was done slowly due to the water depth of approx. 50 metres and the speed of the drifting ship.

At 2225, the crew members on PARIDA had let out the starboard side anchor and chain fully with eight shackles on the sea bottom. The ship's distance to BEATRICE ALPHA was 13 nautical miles. Though the entire length of the starboard anchor chain was in the water, it had no effect. PARIDA continued drifting at a speed of 3-4 knots. The master therefore decided to let out the port side anchor. At 2310, the port side anchor and three shackles of anchor chain had been let out and the master observed that the drift was significantly reduced.

On 8 October 2014 at approx. 0400, PARIDA reached its closest proximity to BEATRICE ALPHA. The distance at that time was approx. 9 nautical miles (figure 9).

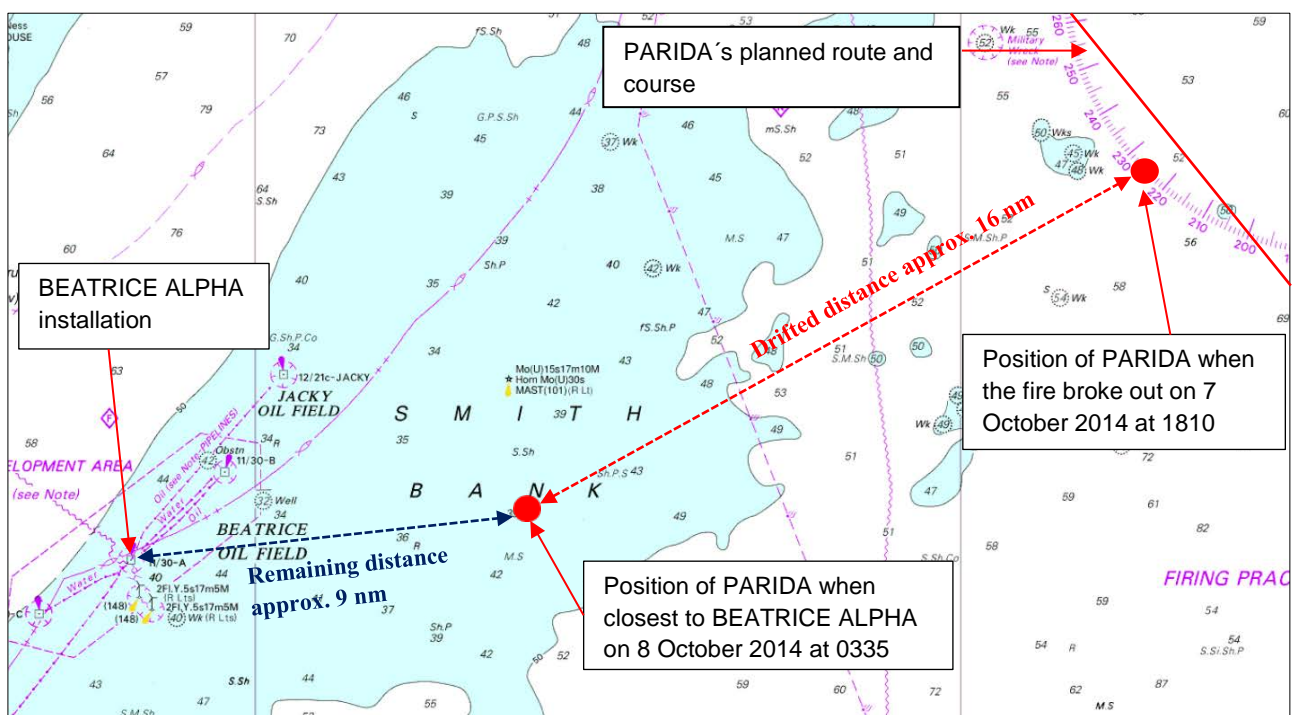


Figure 9: PARIDA's path during drifting

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3.2.6 Recovery of PARIDA

While PARIDA was drifting, the company emergency management team had made contact with a local broker company to arrange for tug boat assistance. Furthermore, a number of ships in the vicinity of the casualty site that had responded to the urgency (PAN PAN) message broadcast by Shetland MRCC offered their assistance.

The government-operated emergency towing vessel (ETV), operating in the area, intended for salvage of ships in distress, to prevent environmental damage, was tasked with assisting in the salvage of PARIDA. However, the ETV was too far away from PARIDA to be considered an effective solution to the immediate situation as the expected time of arrival was not until 0500 the following morning.

At 2320, one of the responding ships, the tug/supply vessel PACIFIC CHAMPION (figure 10), was tasked with assisting PARIDA and proceeded at best speed towards PARIDA's location. The instruction received by PACIFIC CHAMPION was to tow PARIDA in the direction of Cromarty Firth.



Figure 10: PACIFIC CHAMPION
Source: Swire Pacific Offshore

On 8 October 2014 at 0010, PACIFIC CHAMPION advised PARIDA that the ship had an expected arrival time within one hour. On PACIFIC CHAMPION the crew prepared for the connection of the towline in the adverse weather conditions.

At 0325, PACIFIC CHAMPION's tow wire was connected to the emergency towing bollard on board PARIDA. Shetland MRCC was informed that the connection had been made. The weather conditions, with a wave height of 5-6 metres, during the connecting of PARIDA and PACIFIC CHAMPION made the operation challenging and time-consuming (figure 11).



Figure 11: PACIFIC CHAMPION approaching PARIDA to connect tow wire
Source: Swire Pacific Offshore

At 0405, PACIFIC CHAMPION commenced the towing of PARIDA towards Cromarty Firth (figure 12).

Throughout the passage under tow, the crew on board PARIDA inspected the cargo and its lashings on two occasions. They were found unaffected by the conditions.

As PACIFIC CHAMPION and PARIDA approached Cromarty Firth, they were instructed by the port authorities to proceed to an anchorage outside of the port limits where PARIDA dropped anchor at 1045 (figure 12). PACIFIC CHAMPION disconnected its tow wire from PARIDA and remained standby until 1930.

At 1950, two tugs approached PARIDA in order to tow the ship to a berth in the Port of Cromarty Firth. The tugs EINAR and ERLEND connected their tow lines in each end of PARIDA and the ship's anchor was weighed. Once the anchor had been cleared, the tow proceeded towards the port. Shortly after, a pilot boarded PARIDA and the tow continued under pilotage. PARIDA was all fast at the berth at 2210 (figure 12).

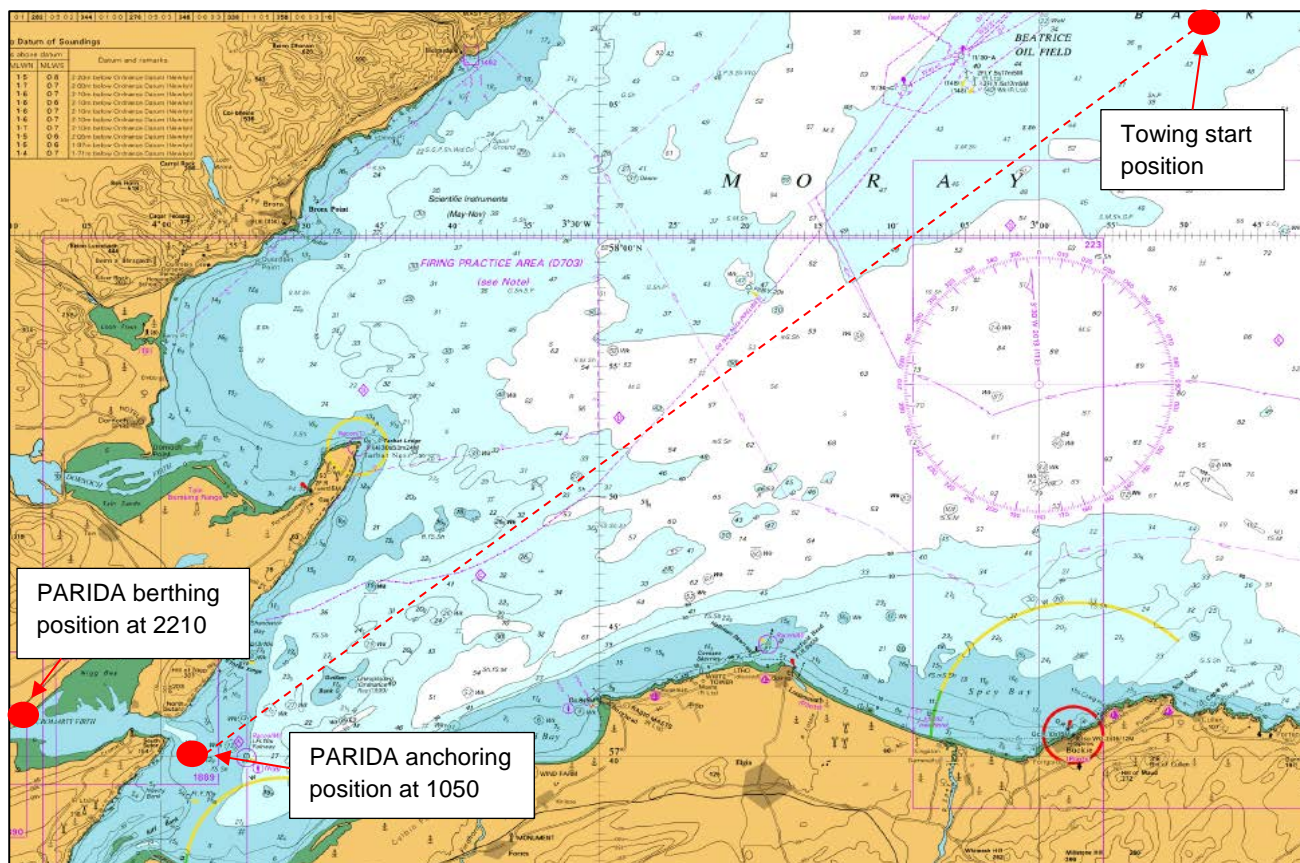


Figure 12: Towing of PARIDA to Cromarty Firth

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3.2.7 The evacuation of BEATRICE ALPHA

The broker who was contacted by PARIDA's owners' representative, and asked to assist in arranging towage for the ship contacted the Maritime and Coastguard Agency (MCA) to inform about the enquiry and to make sure that the nature of the situation was known to the MCA.

The head of the Maritime & Coastguard Agency (MCA) Counter Pollution Branch at first believed that the incident was in the geographical area of Aberdeen MRCC. They were contacted and asked if they were aware of the situation, which they were not. Information about the incident was forwarded to Shetland MRCC which was also unaware of the situation.

At 2003, PARIDA was contacted by Shetland MRCC on VHF channel 16 as it was now clear that the incident took place inside their geographical area of responsibility. Shetland MRCC received detailed information about the situation from PARIDA.

At this point in time, the MCA Duty Counter Pollution and Salvage Officer (DCPSO) was engaged in the process of facilitating tug assistance to PARIDA, while the duty officer at Aberdeen MRCC started to determine the potential risk to the oil and gas assets in the area, constituted by the drifting ship. Taking into account the prevailing weather and sea conditions, it was evident that the BEATRICE OIL-FIELD would be the only asset at potential risk. However, threats to oil-field installations imposed by drifting ships and other occurrences generally involving oil and gas installations were a familiar issue to Aberdeen MRCC. On this basis, the rescue coordination actions were divided between Shetland MRCC and Aberdeen MRCC. Shetland MRCC was tasked with handling the aspects of the situation related to PARIDA, while Aberdeen MRCC was tasked with handling the threat to, and coordination of a possible evacuation of the manned oil production installation BEATRICE ALPHA.

At 2023, the Search and rescue Mission Coordinator (SMC) at Aberdeen MRCC made contact with the Offshore Installation Manager (OIM) on BEATRICE ALPHA. The OIM was made aware of the potential threat to the installation and in return passed on the particulars of the current oil-field operations, including manning of the installations.

At 2109, BEATRICE ALPHA made contact with Aberdeen MRCC requesting a situation update and enquiring about the helicopters to be used in case of an evacuation. It was established that the weather conditions would not allow civil helicopter resources available to land on BEATRICE ALPHA. The OIM, therefore, regarded the situation as an emergency that would require rescue helicopter assistance.

At this time PARIDA was approx. 13.6 nautical miles away from BEATRICE ALPHA. If PARIDA's speed remained unchanged, the closest point of approach would occur 3-4 hours later.

The SMC at Aberdeen MRCC initiated the process of identifying options and allocation of resources for evacuation of the installation.

Only a few minutes later, the OIM on BEATRICE ALPHA announced that the personnel would muster in preparation for an evacuation. The SMC at Aberdeen MRCC advised Shetland MRCC about the events on BEATRICE ALPHA and expressed the urgent need for actions to halt the drifting of PARIDA.

At 2120, the SMC at Shetland MRCC advised Aberdeen MRCC that the crew members on board PARIDA expected to be able to anchor within the next half an hour.

Immediately after, the OIM on BEATRICE ALPHA requested mobilization of helicopter assistance for down manning of the installation. The SMC at Aberdeen MRCC advised the OIM about the time frame of the intended anchoring of PARIDA and a review of the situation was agreed when this time frame had passed.

At 2125, contact was established directly from BEATRICE ALPHA to PARIDA. The crew on board PARIDA informed the platform that there was a distance to the platform of 11 nautical miles and a speed over ground of three to four knots. Aberdeen MRCC was contacted again by the personnel on BEATRICE ALPHA with a request for initiation of down manning by helicopters. The SMC advised that the effects of anchoring of PARIDA would be evaluated before the stand by helicopters would be tasked for the down manning.

Half an hour later, the OIM again requested a down manning. Aberdeen MRCC responded that the down manning would be initiated no later than at 2300 in case the risk of allision remained evident at that time. Immediately after, Shetland MRCC contacted PARIDA and instructed the master to initiate anchoring promptly despite the ongoing efforts to restore propulsion power.

At 2225, one anchor had been deployed from PARIDA. This proved ineffective, in slowing down the drift, and the need for deployment of another anchor was advised by the ship to Shetland MRCC and subsequently relayed to BEATRICE ALPHA. The SMC at Aberdeen MRCC advised BEATRICE ALPHA that evacuation of the platform by helicopter was initiated. Even if the SMC considered the time frame to be well sufficient for a controlled evacuation, the potential threat to the platform was considered more imminent in the light of the failed attempt to stop the drift of PARIDA by anchoring.

At 2325, the first rescue helicopter, R137, landed on BEATRICE ALPHA followed by the second rescue helicopter, R102, at 2344. The personnel evacuated from the installation were flown to the nearby Lossiemouth Royal Air Force base (figure 13). Both rescue helicopters returned to BEATRICE ALPHA for another personnel evacuation. At 2354, the installation was completely evacu-

ated as R102 departed with the last personnel. On 8 October 2014 at 0022, all 52 persons from BEATRICE ALPHA were accounted for at Lossiemouth.

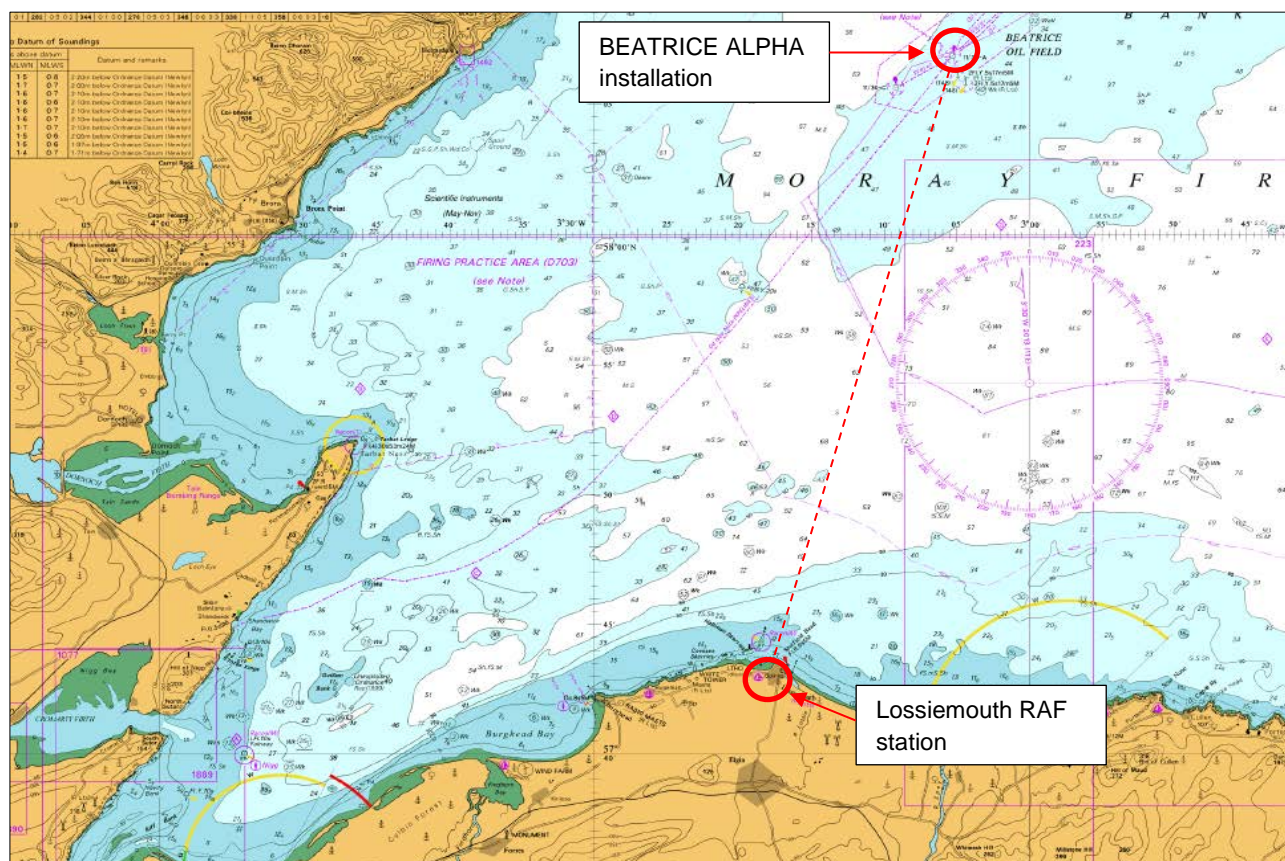


Figure 13: BEATRICE ALPHA evacuated to Lossiemouth RAF station

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3.2.8 Temporary repairs on PARIDA

When PARIDA arrived in Cromarty, the ship was inspected by the port State, the flag State, classification society and company representatives. It was agreed that temporary repairs should be made in order for the ship to complete a trip to Antwerp, to discharge the cargo as per the original plan and subsequently have the ship repaired permanently. In order to obtain the permission for the single voyage to Antwerp, the thermal heat-oil system was bypassed, drained from oil and ventilated. Cleaning of the funnel space was carried out to remove oil residues and firefighting water. The electrical power to the funnel area was isolated and a temporary aft navigational light was installed as well as temporary wiring to a smoke detector in the funnel area as the original wiring was burned. The fire damper flaps in the funnel area were secured in a permanently closed position as a temporary measure, because the remote closing system had been damaged.

A further condition for the single voyage permission to Antwerp was that PARIDA was to be assisted by a sufficiently strong tug on departure from Cromarty Firth and upon arrival in Antwerp.

3.2.9 The second fire on PARIDA

After the temporary repairs had been completed, PARIDA departed the Port of Cromarty Firth on 10 October 2014 bound for Antwerp. The main engine had been configured to run on marine gas oil because the thermal heat-oil system had been isolated from the rest of the engine plant and was, therefore, not able to produce heat to ensure the correct viscosity of the heavy fuel oil. Two superintendents from the company had joined the ship for the voyage to Antwerp, Belgium.

At 1625, PARIDA was underway with a pilot on board and escort assistance from a local tug boat ordered by the ship owner in accordance with the class conditions to follow the ship until it had reached a distance of 30 nautical miles off the coast. A crew member was stationed near the funnel to monitor any irregularities.

Half an hour later, PARIDA proceeded through the entrance to Cromarty Firth and into the open sea. At the same time, the watchman by the funnel alerted the bridge about the observation of smoke development and small flames from the exhaust gas boiler in the funnel. Firefighting efforts were quickly initiated and the fire was immediately extinguished by means of portable fire extinguishers. When PARIDA was outside the entrance to Cromarty Firth, the pilot disembarked. One of the superintendents established that the fire had most likely originated from oil contaminated insulation in the lower part of the exhaust gas boiler. It was decided to proceed to a good anchoring position, drop anchor and sanitize the exhaust gas boiler further. The master contacted the company and informed the local authorities about the situation and the crew members' intentions.

At 1800, PARIDA started dropping anchor. Five minutes later, seven shackles had been let out and PARIDA was anchored.

The crew members initiated stripping of some oil soaked insulation from the exhaust pipe and exhaust gas boiler at the bottom of this (figure 14). A thorough cleaning of the area was also carried out. Upon completion the crew members prepared to resume the voyage towards Antwerp. A permanent watch was stationed inside the funnel casing.



Figure 14: Bottom of exhaust gas boiler with removed insulation
Source: Harren & Partner/DMAIB

At 2110, the crew members started heaving up the anchor. 15 minutes later, PARIDA proceeded towards the planned route to Antwerp. As a precaution following the fire on board on 7 October 2014, the voyage had been planned to keep the ship well clear of the shoreline.

On 13 October 2014 at 0530, PARIDA arrived safely and made fast in Antwerp. The cargo was discharged and the crew members took bunkers and prepared to shift from the berth to Antwerp Shipyard.

3.3 General layout of PARIDA

PARIDA was a heavy lift carrier/ro-ro ship equipped for carriage of containers in the hold and on the hatch covers. The cargo handling gear consisted of two 120 tons cranes. The ro-ro ramp was located at the aft end of the ship, allowing vehicles to drive onto the tween deck in the cargo hold. In the forward part of the cargo hold, there was a lower hold below the tween deck level.

The accommodation was placed in the forward end of the ship and the engine room was located below the tween deck level in the ro-ro cargo space in the aft end of the ship. In between was the cargo space. The general layout is shown in figure 15.

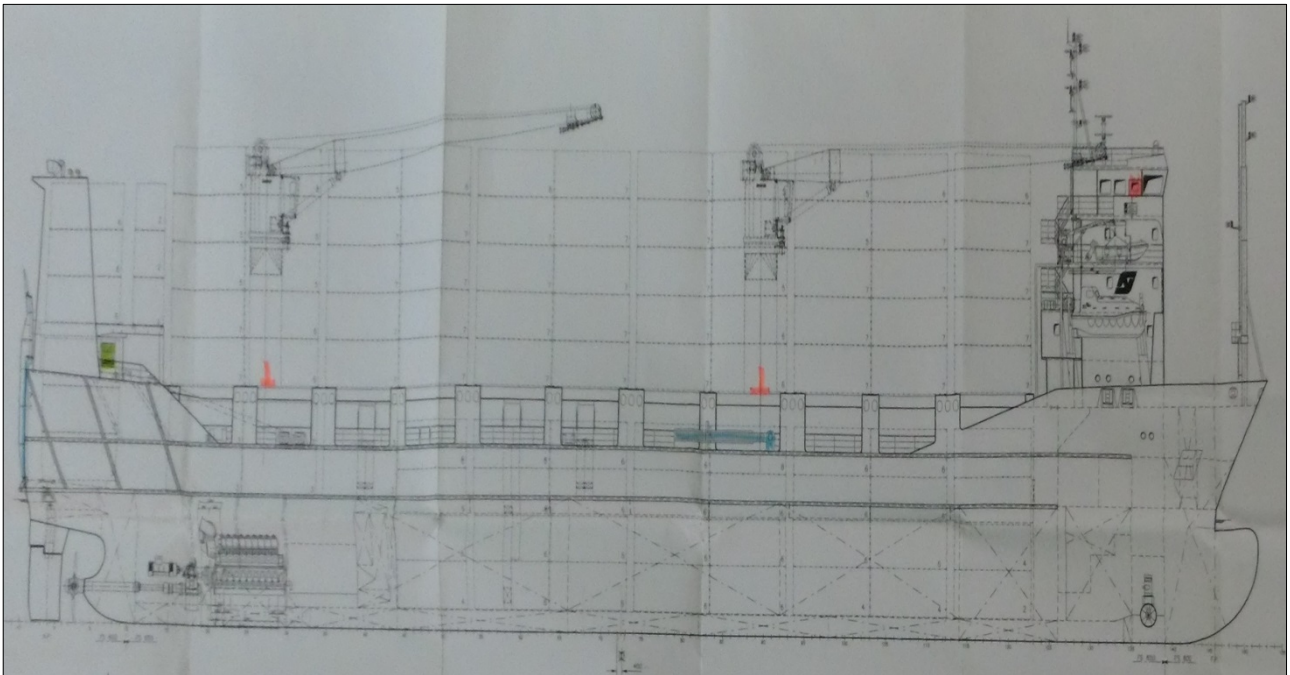


Figure 15: PARIDA general arrangement
Source: Harren & Partner

PARIDA left Scrabster on the day of the accident with a draft of 4.6 m aft and 4.2 m forward. The design draft was 6.93 m. The relatively low draught on the day of the accident is likely to have made the aft part of the ship particularly susceptible to slamming from the sea during the prevailing weather conditions as the bottom of the aft ship would have been exposed in a way similar to what can be seen in figure 16. In the picture, the ship is shown alongside with approximately the same draught that it had on the day of the accident.



Figure 16: Aft end of PARIDA susceptible to slamming
Source: DMAIB

3.4 Origin and development of the fire

3.4.1 The scene of the fire

The funnel casing was located aft in the starboard side of the ship (figure 15). The space inside the funnel casing was entered through a door from the aft deck. Part of the ship's thermal heat-oil system equipment including the exhaust gas boiler was located inside the funnel casing space. A general layout of the components is seen in figure 17 below.

From the entrance, a stairway led to a lower level where access to the upper part of the exhaust gas boiler was gained. The pressure gauge that came off was fitted on the heat-oil inlet pipe to the exhaust gas boiler, also located on this level. Under the stairway, on the forward bulkhead, electrical wiring was connected in a mounted junction box.

From the lower level access to an auxiliary machinery room at the bottom of funnel casing, the hydraulic room, was gained.

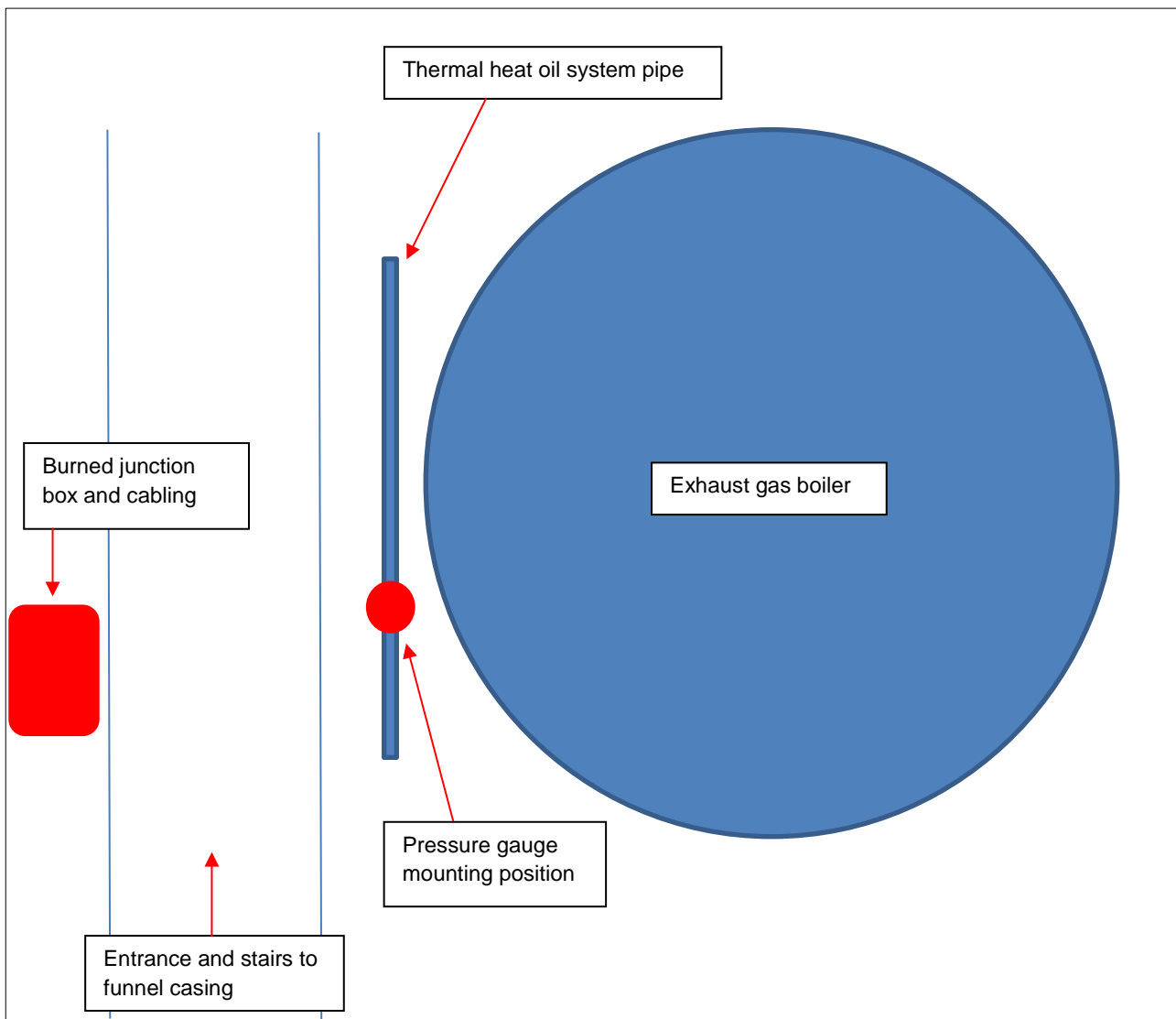


Figure 17: Funnel casing interior
Source: DMAIB

The exterior of the funnel casing was clearly heat affected in such a way that the paint had peeled off in some places. The sealing on the entrance door to the casing had partly melted (figure 18).

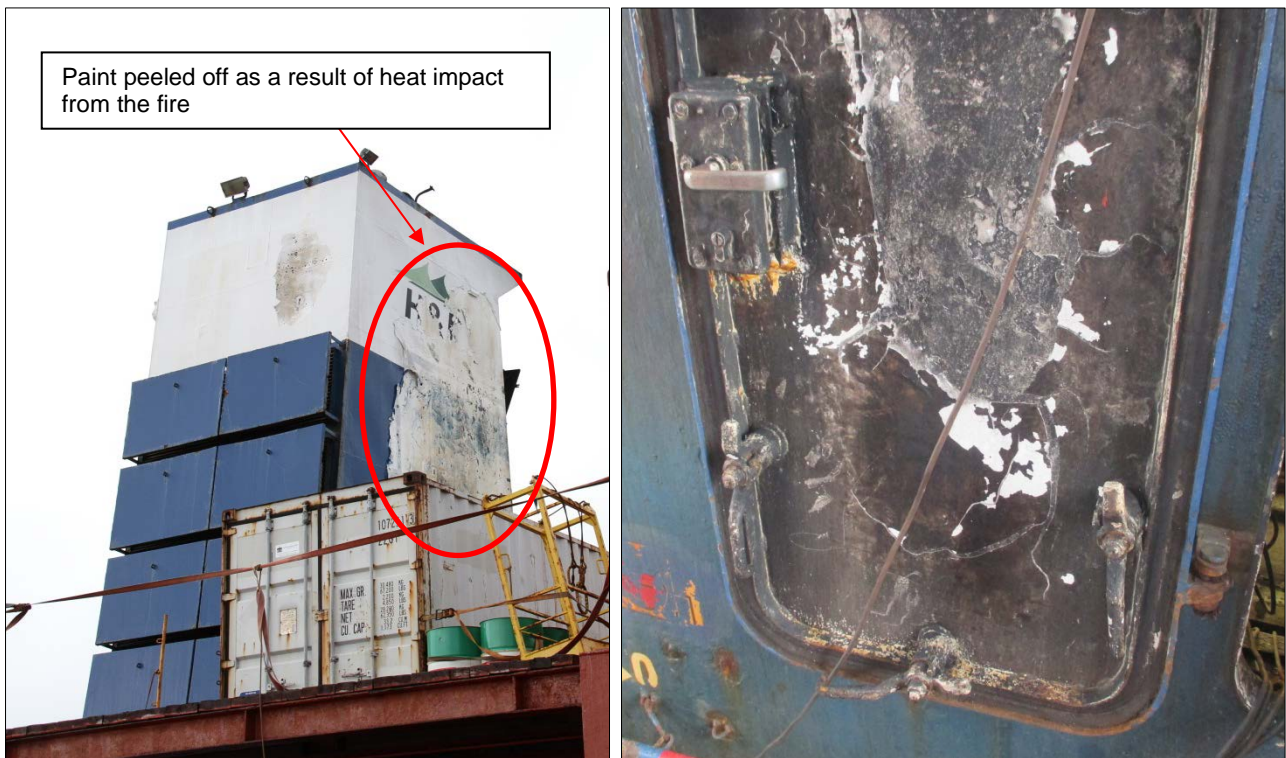


Figure 18: Exterior of funnel casing and entrance door to casing
Source: Harren & Partner/DMAIB

The inside of the casing was substantially damaged by the fire. Particularly on the forward and starboard side bulkheads, the paint had been burned and soot covered the bulkheads. Insulation on electrical wires was burned in several places. The electrical sensors and actuators on the thermal heat-oil components had been destroyed. The insulation material used on the piping was damaged by the fire in several places. The exhaust gas boiler appeared to have suffered only minor damage (figures 19 and 20).

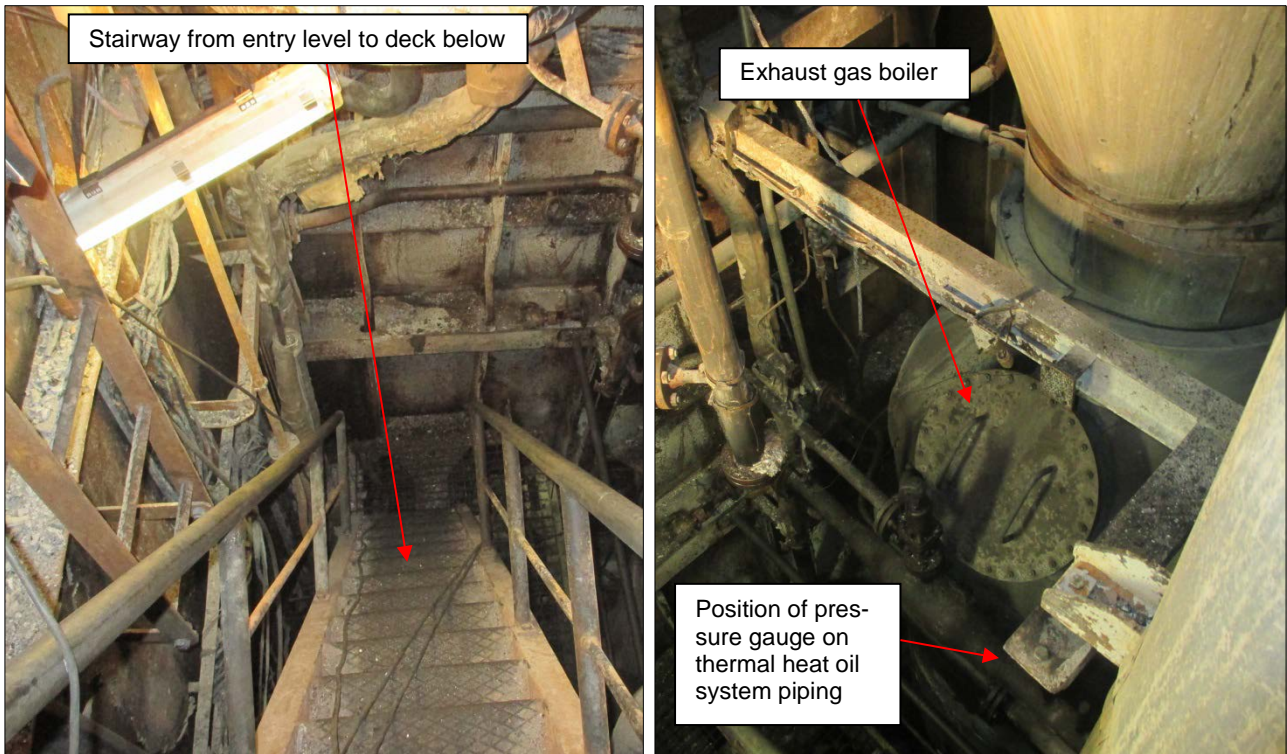


Figure 19: Left: View ahead when entering the casing after the fire. Right: View to the right side (exhaust gas boiler)
Source: Harren & Partner/DMAIB

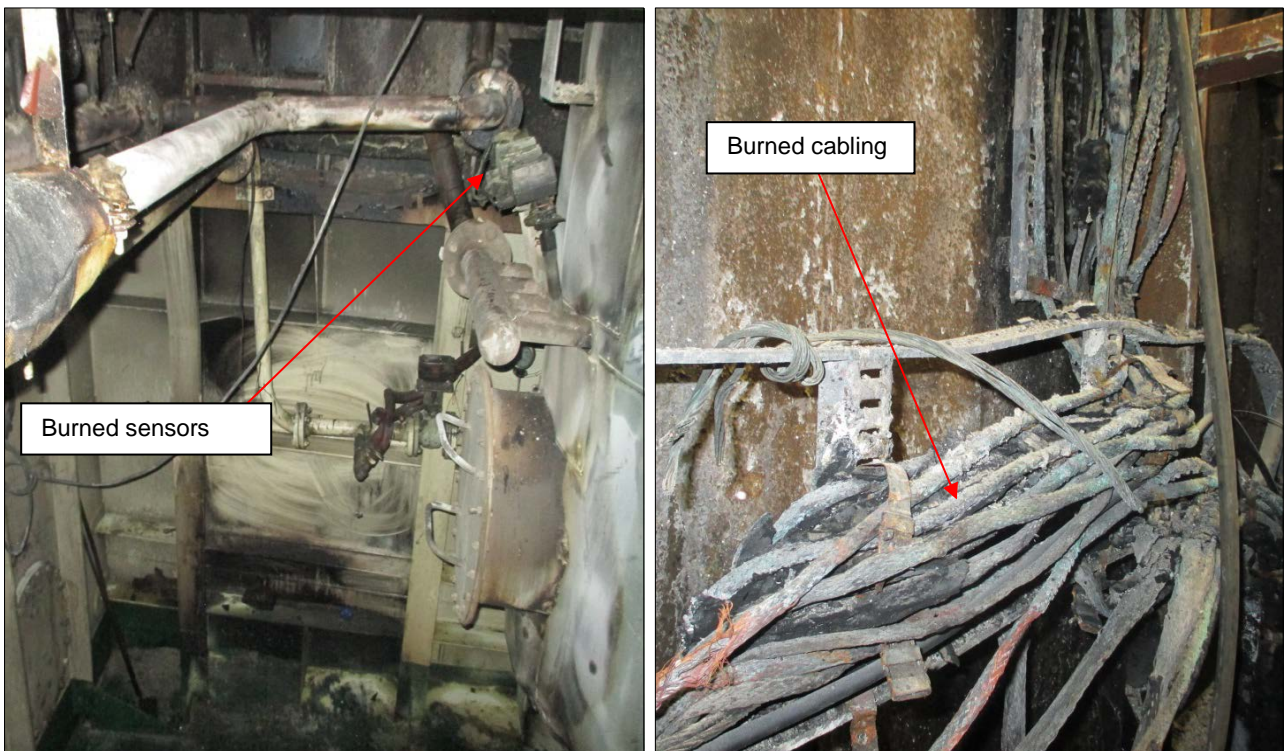


Figure 20: Burned sensors and wiring for the thermal heat oil system in the casing area
Source: Harren & Partner/DMAIB

Under the stairs the electrical junction box, mounted on the forward bulkhead, had been completely destroyed by the fire. Only remains of the wiring and the mounting brackets remained (figure 21).

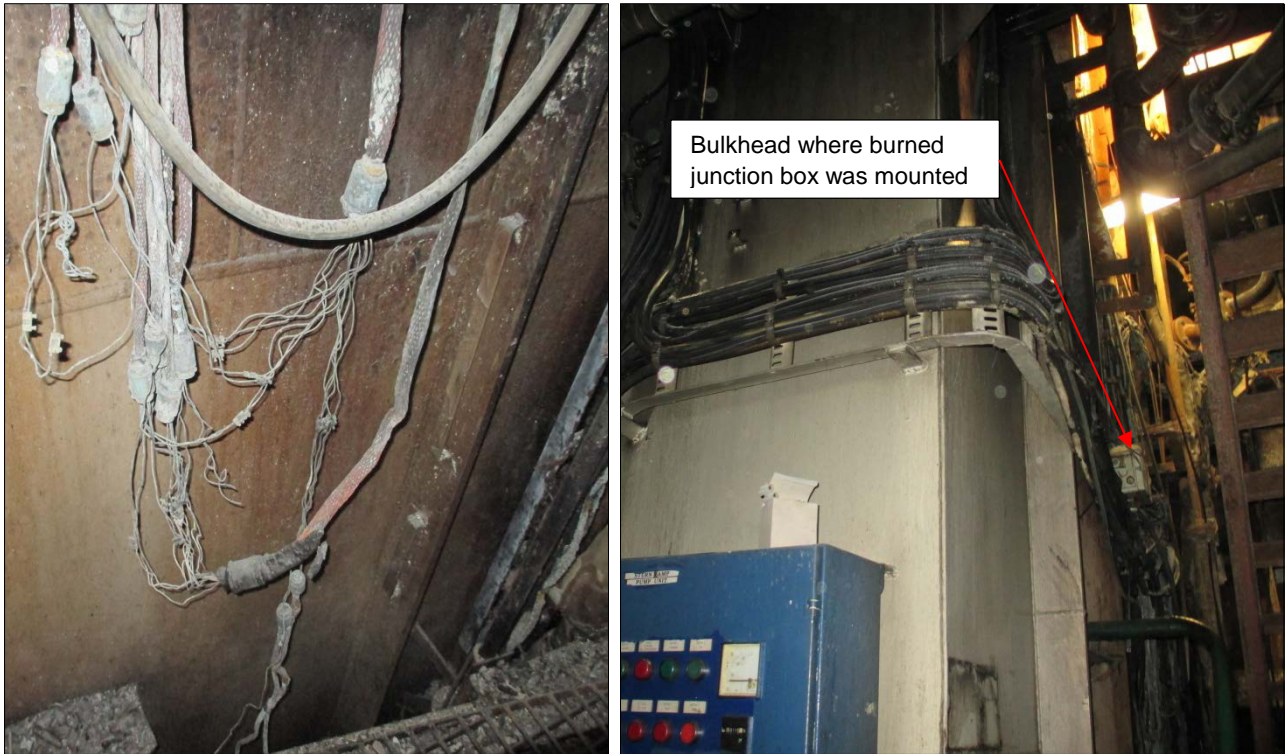


Figure 20: Left: Remains of wires from junction box. Right: Bulkhead left of stairway where junction box was mounted, seen from half level down.

Source: Harren & Partner/DMAIB

There was no automatic fire detection equipment installed on this level of the funnel casing or at any level above.

An automatic smoke detector installed in the hydraulic room was found inoperable during a port State inspection following the fire, likely due to the damage to the electrical cables in the funnel casing. The room appeared to be contaminated by soot, but no immediate fire damage was apparent.

3.4.2 Origin of the fire

The pressure gauge came loose and fell off, possibly due to the motions in the aft ship induced by slamming. The oil sprayed into the area at a pressure equivalent to the system pressure of approx. 8 bars. The oil was then ignited by an ignition source present in the area.

Based on the crew's observations in relation to the second fire, it was established that it was possible for the oil to reach the surface of the exhaust pipe, despite its insulation, and that the exhaust pipe was sufficiently hot to ignite the oil.

In the product data sheet, the auto-ignition temperature of the thermal heat-oil was stated as 357°C. The exhaust gas inlet temperature specified in the technical and safety description for the exhaust gas boiler was stated as 335°C. The temperature of the surface of the exhaust pipe would need to rise to the auto-ignition temperature to ignite the oil. There was no reading of the thermal heat-oil exhaust gas boiler inlet temperature on the system. However, the second fire showed that this temperature was reached. It is therefore possible that the first fire ignited in the same place.

3.4.3 Fire development

In general, the development of a fire and the resulting damage is most extensive in an area where there is a presence of combustible material. However, this does not necessarily reveal the origin of the fire. Therefore, there may not be a close connection between the location of the point of ignition and the location where the fire developed most extensively and caused the greatest damage, i.e. junction box, wiring and light fixtures.

In the early stages of the fire on PARIDA, hot thermal heat-oil sprayed into the casing area continuously, thereby fuelling the ignition and the spreading of the fire – possibly through contact with the hot surface of the exhaust boiler. It is uncertain for how long the circulation pumps provided pressure before the system malfunctioned due to the effect of the fire on the thermal heat-oil system's sensors and their wiring.

It has not been possible to establish the exact spreading of the fire because the fire did not only develop by means of solid combustible materials present in the casing area, but also by means of oil under pressure.

3.4.4 Alternative sources of ignition

In the casing area, several electrical installations were found to be burned, including the junction box where the electrical wiring to the 24-volt thermal heat-oil sensor system was connected. Based on the glands visible on the electrical cables after the fire, the junction box appears to have been encapsulated at a level equivalent to IP 44 which protected the junction box against water ingress and particles.

With the presumed capsuling, it is unlikely that sufficient thermal heat-oil would have entered the junction box to cause a short circuit. There is no reason to suspect that the oil¹ was electrically conductive at a level that would substantiate such a short circuit caused by the oil. Neither is it probable that the oil itself would have been able to ignite substances such as electrical wiring, etc. as the operating temperature of the thermal heat-oil was only stated as being between 140°C and 180°C.

Therefore, it is unlikely that the ignition source is the combined effect of oil inside the burned electrical junction box. However, it cannot be dismissed that two simultaneous events combined to create the fire; one being the pressure gauge unscrewing from the fitting on the pipe, and the other being electrical arcing inside, and subsequent burning of either the particular junction box, a fluorescent light fixture or another electrical installation in the casing area.

Both events could have been caused by the vibrations and other vessel movements in this particularly exposed part of the ship. Arcing inside fluorescent light fixtures has previously been investigated by the DMAIB and found to have initiated fires, e.g. on board the Danish passenger/ro-ro ship URD².

3.5 Loss of propulsion

3.5.1 Consequences of the fire

It was established that due to pipe dimensions, the oil leaking from the open end of the pressure gauge piping, likely did not reduce the oil flow in the system to 85 %. This would have been necessary to cause a drop in the flow safety device differential pressure, from 0.35 bar to 0.25 bar, which would activate the low flow alarm. Therefore the heat-oil system's circulation pump did not stop when the pressure gauge came off and the oil continued to spray into the funnel casing.

¹ Castrol Perfecto HT 5.

² DMAIB (2014), *URD Fire*. Available from:

<http://www.dmaib.dk/Ulykkesrapporter/URD%20Marine%20accident%20report.pdf>.

During the fire several of the thermal heat-oil system components that were located in the funnel casing area, were severely damaged. The damaged sensor cabling initiated the alarm sequence in the control system when the connection to the panel and the power to the sensors were lost. This resulted in the shutdown of the thermal heat-oil circulation pump and the triggering of the flow safety alarm.

The low flow alarm was connected to the main engine safety system and triggered the automatic slowdown mode on the main engine. This reduced the propeller pitch and thereby the load on the main engine to protect the exhaust gas boiler from overheating without the flow of oil through the thermal heat-oil system.

The thermal heat-oil system was designed to allow emergency dumping of the thermal heat-oil from the expansion vessel in the casing to a drain tank. This was not considered feasible by the chief engineer because of the presumed explosion hazard that this process would present. It has, however, been established that it would not have been possible to dump the oil because the pneumatic actuators operating the emergency drain valve system had been rendered inoperable by the fire.

3.5.2 Restoring of propulsion

As a result of the damage to the system's sensors and wiring, there was no 24 V control power and therefore no sensor feedback on the cabinet. From inspections of the systems located at the scene of the fire, it was eventually established that the engineers would not be able to restore normal functioning of the thermal heat-oil system during the emergency.

The engine crew were hesitant in their attempts to restore the propulsion power as it could present a risk of re-igniting the fire. The crew were unable to ensure that residual thermal heat-oil in the funnel area would not present a fire hazard if the main engine was re-started.

The breakdown of the thermal heat-oil system had generated the slowdown mode on the main engine. There was no immediate measure to be taken to reset or override this safety function as this required specific knowledge about system reconfiguration. At one time during the unfolding events, a procedure for reconfiguration of the plant was supplied to the ship by the manufacturer of the thermal heat-oil plant. The purpose of the procedure was to restore propulsion with a bypassed exhaust gas boiler; however, this option was abandoned because of the fire hazard, and the ongoing anchoring efforts and tug boat arrangements seemed more promising given the threat of collision with BEATRICE ALPHA. The procedure was eventually used to reconfigure the ship while PARIDA was in Cromarty being temporarily repaired in preparation for the voyage to Antwerp.

3.6 Irradiated nuclear cargo

At the time of the accident, PARIDA held an international certificate of fitness for the carriage of INF cargo issued by the ship's classification society on 21 August 2014, valid until 25 May 2019. This allowed the ship to carry radioactive substances in accordance with the INF Code (International Code for the Safe Carriage of Packaged Irradiated Nuclear Fuel, Plutonium and High-level Radioactive Wastes on Board Ships). Thus, the ship was allowed to carry packaged irradiated nuclear fuel, plutonium and high-level radioactive wastes as cargo in accordance with class 7 of the IMDG Code. The INF Code specified three classes of radioactive cargo of which PARIDA was certified to carry the lowest radiation class called INF 1. This meant that the ship could carry cargo with a radioactivity level less than 4000 TBq³. For comparison INF 2 allows a corresponding level of 2×10^6 respectively 2×10^5 . INF 3 allows carriage of cargo with no maximum radioactivity level.

Different structural, technical and operational requirements are defined by the INF Code, varying for the certification of ships to the three distinguished INF classes.

³ TBq is the abbreviation of TerraBecquerel, which is the unit used to measure radioactivity.

The cargo loaded on board PARIDA in Scrabster prior to the fire consisted of two identical trailers, each loaded with a cement cask containing hazard class 7 radioactive materials, UN no. 2916. Each loaded trailer weighed 35383 kg, of which 3870 kg was the radioactive material.

According to the cargo manifests, the total level of radioactivity from each trailer was measured to 58.9 TBq.

The DMAIB has received the following information about the cargo on board PARIDA from the National Institute of Radiation Protection at the Danish Health and Medicines Authority:

The Danish Maritime Accident Investigation Board has asked the National Institute of Radiation Protection at the Danish Health and Medicines Authority to assist in the assessment of the significance of the nature of the cargo shipped by PARIDA, with respect to the emergency measures that were put in place during the fire aboard the INF classified ship in October 2014.

The INF Code is strictly speaking irrelevant in the given case. As the INF abbreviation means: "Irradiated Nuclear Fuel" it merely reveals that PARIDA was in fact certified to transport even more hazardous material, such as Irradiated Nuclear Fuel of class 1 (INF 1). This was however not the case.

In the present case the transported goods was radioactive waste, shipped as: UN-2916, Radioactive Material, Type B(U) Package, Class 7. The radioactive material was in solid form: It was embedded or cemented into a solid matrix, making it very unlikely to spread in the case of an accident.

The solid radioactive material was shipped in type B packages; the B(U) variant, which means that they were only subject to approval in the country of origin. Type B packages are tested to withstand transport accidents, such as dropping, penetration, fire etc. in order to prevent leakage of radioactive material, even in severe accidents.

The amount of radioactive material (the activity) in the packages (59 TBq) is comparable to the activity in a single blood irradiation facility, commonly used in most hospitals for sterilizing blood. The amount of gamma radiation – the dose rate – at a distance of 1 meter from each of the packages is approximately 12 $\mu\text{Sv/h}$. This is a low dose rate; for instance much lower than the dose rate from a patient in ordinary treatment with radioactive iodine.

Finally it should be mentioned that many of the radioactive nuclides in the material are of such a nature that they are unable to emit radiation outside the container, as they are alpha- and beta emitters.

4. ANALYSIS

The accidental events involving PARIDA went through three stages: The fire, the engine immobilization and the uncontrolled drift towards BEATRICE ALPHA.

The first stage involved the actual fire in the funnel casing triggered by an unscrewed pressure gauge in the thermal heat-oil system. This allowed oil to enter the area and ignite upon contact with the source of ignition, which was likely the hot surface of the exhaust gas boiler inlet pipe.

The second stage was a consequence of the first; the thermal heat-oil system was substantially damaged by the fire, which caused the activation of main engine slowdown function. Restarting the engine was delayed because of the engine crew's concerns about re-igniting the fire and uncertainty about the general condition of the engine room systems.

In the third stage, PARIDA was adrift in the direction of the nearby oil production platform BEATRICE ALPHA, which was eventually shut down and evacuated. The situation was stabilized as PARIDA's drift was halted and it was taken under tow to the nearby port in Cromarty Firth.

4.1 Fire and firefighting

The crew were able to quickly extinguish the fire due to the early discovery of the fire and the quick response and because the thermal heat-oil system stopped.

The fire was discovered visually by the crew members on board PARIDA before receiving any alarms. The funnel casing was fitted with one automatic smoke detector, but this was located in the hydraulic room below the level where the fire developed most intensely. Therefore, the purpose of giving an early warning about a fire in this area was not fulfilled by the smoke detector. The smoke would need to develop substantially to fill the space below before activation of the smoke/heat detectors.

The fire alarm system was not fitted with a log and, therefore, it is uncertain if a fire alarm was activated on the fire control panel on the bridge or whether only a fault message was indicated due to damage to the wiring to the smoke detector caused by the fire. During a larger fire scenario, the absence of a fire detector log is disadvantageous and offers little support in the efforts to keep track of the development and spreading of the fire.

After the discovery of the fire at approx. 1800, the crew initiated firefighting at 1815, and the fire was extinguished at 1835. Within the 35 minutes, the fire did not spread and/or reach a critical temperature to render the deployed firefighting resources insufficient for extinguishing and/or containing the fire. Under the given circumstances with adverse weather conditions and the distance between the accommodation and the funnel casing, the relatively short response time of 15 minutes was essential for extinguishing the fire. The prompt closing of the ventilation and main engine that would draw air into the engine room was also instrumental for the containment of the fire.

The main fuel to the fire, the thermal heat-oil, was cut off by the thermal heat-oil system because the sensors and their wiring were damaged by the fire causing the circulation pumps to stop. Apart from the thermal heat-oil, the funnel casing contained a limited amount of combustible material that would ignite at relatively low temperatures during the early stage of the fire.

The emergency quick release valves that were designed to enable the oil to be dumped to the drain tank during an emergency malfunctioned as a result of the fire. The emergency situation that the quick release valves were designed to mitigate thus rendered the valves inoperable. This illustrates well how it can be difficult to design safety features for situations where complexity increases by unexpected interconnections between the accidental events and safety system components.

4.2 Loss of propulsion and drift

The damage and subsequent shutdown of the thermal heat-oil system immobilized the main engine which resulted in the ship drifting uncontrollably. The thermal heat-oil plant and the main engine systems were interconnected in such a way that the continuous operation of the main engine was not possible. The malfunctioning thermal heat-oil system could sustain even further damage from such continued operation without a flow of oil through the thermal heat-oil system. Therefore, a safety feature of the thermal heat-oil system triggered the slowdown mode on the main engine to reduce system load. The condition of the thermal heat-oil system in combination with the perceived further risk of a new fire in the casing made operation of the propulsion plant inexpedient.

For the engine crew on board PARIDA, the ongoing attempts to restore the propulsion was embedded in their training as engineers and the objective was to avoid an allision with BEATRICE ALPHA or the grounding of the ship. The incentive for continued efforts was, therefore, strong. However, the need for other actions in order to mitigate the risks associated with the drifting of the ship was acknowledged. Such mitigation was attempted by deployment of the anchors which eventually successfully brought PARIDA to an almost halt. The successful outcome of the anchoring was not given beforehand as the anchors are not designed to stop a drifting ship in adverse weather conditions as described in the Rules for Classification of Ships⁴:

The anchoring equipment required is the minimum considered necessary for temporary mooring of a vessel in moderate sea conditions when the vessel is awaiting berth, tide, etc. The equipment is therefore not designed to hold a vessel off fully exposed coasts in rough weather or for frequent anchoring operations in open sea. In such conditions the loads on the anchoring equipment will increase to such a degree that its components may be damaged or lost owing to the high energy forces generated.

The anchors eventually slowed down the drift of PARIDA and, to some extent, stabilized the situation by removing the immediate threat of allision with BEATRICE and provided time for PARIDA to be assisted by PACIFIC CHAMPION.

As PARIDA drifted uncontrollably, the perception by Aberdeen MRCC of the risk to BEATRICE ALPHA increased and the evacuation and shutdown of the installation went from being a potential course of action to an actual risk mitigation resulting in the evacuation of the installation.

The distance between the drifting ship and the oil production platform gave a sufficient buffer in time and distance to initiate a shutdown and evacuation of the platform to minimize the potential damage in the event of allision. It also allowed the mitigation of the situation on board PARIDA by deployment of the anchors and subsequent salvage by means of tug assistance. Furthermore, the distance allowed changes in the environment, e.g. a shift in the wind direction, which could influence the outcome of the events. The distance between PARIDA and BEATRICE ALPHA and the willingness to mitigate the potential risks associated with the unfolding events were, therefore, a primary condition for the hindrance of the full potential of the accident to unfold.

⁴ DNV Rules for Classification of Ships. Newbuildings, Hull and Equipment Main Class, January 2011, Section 3, Anchoring and mooring equipment.

5. CONCLUSIONS

The fire in the funnel casing on PARIDA likely arose when the weather induced motions, acting on the aft end of the ship, contributed to the unscrewing of a pressure gauge fitted on the ship's thermal heat-oil system. The thermal heat-oil sprayed from the pipe end at high pressure into the funnel casing space where it was ignited, most likely by a hot surface on the exhaust boiler inlet pipe.

Due to interconnection between the thermal heat-oil system and the main engine safety systems, the main engine slowdown mode was activated. The slowdown mode could not be immediately cancelled and there was a perceived continued risk of fire, which in combination resulted in immobilization of the main engine and left PARIDA adrift.

The drifting ship and the prevailing weather conditions posed a risk of an allision with the nearby oil production platform BEATRICE ALPHA. The risk was averted as PARIDA managed to halt the drift by means of its anchors and was subsequently towed into sheltered waters.

The DMAIB has previously noted the perception that anchors are in part intended for use in such emergency situations. However, the standard anchor equipment on board ships generally does not support this purpose. Thus, emergency use of anchors might introduce an excessive strain on the ship's structure and may expose the crew working near the anchor winches to an additional risk.

PARIDA carried radioactive material at the time of the fire. However, the DMAIB's investigation has established that the cargo did not present any particular hazard in relation to the emergency situation.

The fire has demonstrated how a rather small and well-handled fire could result in the potential for a larger disaster. A minor malfunction in a pressure gauge caused a fire that triggered the loss of propulsion. The on board conditions interacted with the environmental conditions and created a risk of allision with BEATRICE ALPHA. Thereby, the accident illustrates how a small everyday malfunction of a technical component can have propagating effects. Furthermore, it establishes that there is not necessarily proportionality between accidental events and their consequences.

6. PREVENTIVE MEASURES TAKEN

The ship-owner has informed the DMAIB about preventive measures taken so far:

- Additional automatic fire detectors have been installed at higher locations inside the funnel casing space, in the area of the thermal heat-oil exhaust gas boiler.
- The thermal heat-oil system vent line has been extended, outside the funnel space.
- The pressure gauge which unscrewed during the incident has been secured with brackets.