Marine Safety Investigation Unit

Transport Malta

MARINE SAFETY INVESTIGATION REPORT

Safety investigation into the serious injury on board the Maltese registered ro-ro vehicle carrier

TORTUGAS

in the port of Teesport, UK on 31 January 2023

202301/030

MARINE SAFETY INVESTIGATION REPORT NO. 02/2024

FINAL

Investigations into marine casualties are conducted under the provisions of the Merchant Shipping (Accident and Incident Safety Investigation) Regulations, 2011 and therefore in accordance with Regulation XI-I/6 of the International Convention for the Safety of Life at Sea (SOLAS), and Directive 2009/18/EC of the European Parliament and of the Council of 23 April 2009, establishing the fundamental principles governing the investigation of accidents in the maritime transport sector and amending Council Directive 1999/35/EC and Directive 2002/59/EC of the European Parliament and of the Council.

This safety investigation report is not written, in terms of content and style, with litigation in mind and pursuant to Regulation 13(7) of the Merchant Shipping (Accident and Incident Safety Investigation) Regulations, 2011, shall be inadmissible in any judicial proceedings whose purpose or one of whose purposes is to attribute or apportion liability or blame, unless, under prescribed conditions, a Court determines otherwise.

The objective of this safety investigation report is precautionary and seeks to avoid a repeat occurrence through an understanding of the events of 31 January 2023. Its sole purpose is confined to the promulgation of safety lessons and therefore may be misleading if used for other purposes.

The findings of the safety investigation are not binding on any party and the conclusions reached and recommendations made shall in no case create a presumption of liability (criminal and/or civil) or blame. It should be therefore noted that the content of this safety investigation report does not constitute legal advice in any way and should not be construed as such.

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International Maritime Organization. (2020). Guidelines for inspection and maintenance of mooring equipment including lines, § MSC.1/Circ.1620 (24 December 2020)

Patriarca, R., & Bergström, J. (2017). Modelling complexity in everyday operations: functional resonance in maritime mooring at quay. *Cognition, Technology & Work*, *19*(4), 711-729. https://doi.org/10.1007/s10111-017-0426-2

Ship management Company

GLOSSARY OF TERMS AND ABBREVIATIONS

°C	Degrees Celsius
Breast line	A mooring rope which runs perpendicular to the vessel from the forward and aft mooring stations to bollards on the jetty, to keep the vessel alongside
DNV	Det Norske Veritas
GMDSS	Global Maritime Distress and Safety System
gt	Gross tonnage
Head line	A mooring rope leading forward from the bow, generally at an angle of 45° to the fore and aft line
kN	Kilonewton
kW	Kilowatt
LDBF	Line design break force
LMP	Electronic line management plan
LT	Local time
m	metres
MARINA	Maritime Industry Authority of the Philippines
mm	Millimetre
MSIU	Marine Safety Investigation Unit
mt	Metric tonne
MV	Motor vessel
nm	Nautical miles
OS	Ordinary seafarer
PMS	Planned maintenance system
ro-ro	Roll-on, Roll-off
RPM	Revolutions per minute
PSCO	Port State Control Officer
Spring line	A mooring rope paid out diagonally from the forward and aft mooring stations, and made fast to bollards on the jetty to stop the vessel from moving forward (headsprings) and aft (back springs) when alongside
SSMM	Wilhelmsen Ship Management Safety Management System
STCW Convention	International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978, as amended

Stern line	A mooring rope leading aft from the stern, often an at angle of 45° to the fore and aft line
UK	United Kingdom
UMS	Unmanned machinery space
USA	United States of America

SUMMARY

On 31 January 2023, *Tortugas* was berthing at Teesport, UK. After one spring line and a breast line were made fast, from both forward and aft, the vessel was advised that it would have to shift ahead by about 10 m.

For the shifting, the officer supervising the forward mooring station was positioned in close proximity to the forward spring line, to monitor it. However, the brake of the mooring winch for the forward spring line had not been loosened and its gear had not been re-engaged. Eventually, the forward spring line parted under tension and consequently, injured the officer.

The safety investigation found that the forward spring line had parted due tensile overload.

The MSIU has not issued any recommendations, following the safety actions taken by the Company.

1 FACTUAL INFORMATION

1.1 Vessel, Voyage and Marine Casualty Particulars

Name	*Tortugas*
Flag	Malta
Classification Society	Det Norske Veritas (DNV)
IMO Number	9319765
Type	Ro-ro vehicle carrier
Registered Owner	Julia Shipping S.A.
Managers	Wilhelmsen Ship Management (Norway) A.S.
Construction	Steel (Double bottom)
Length overall	199.99 m
Registered Length	192.12 m
Gross Tonnage	61,321
Minimum Safe Manning	15
Authorised Cargo	Vehicles, roll on-roll off cargo units
Port of Departure	Tilbury, UK
Port of Arrival	Teesport, UK
Type of Voyage	Coastal
Cargo Information	1,123 mt (238 units) of vehicles
Manning	23
Date and Time	31 January 2023, at 0750 (LT)
Type of Marine Casualty	Serious Marine Casualty
Place on Board	Forecastle (forward mooring) deck
Injuries/Fatalities	One seriously injured crew member
Damage/Environmental Impact	One parted mooring rope / None
Ship Operation	Berthing, under pilotage
Voyage Segment	Arrival
External & Internal Environment	Daylight, clear sky, and a visibility of 10 nm. Moderate to fresh gale force winds from the West, and a moderate sea, with a low, Westerly swell. Air and sea temperatures: 8 ℃ and 6 ℃, respectively.
Persons on Board	25

1.2 Description of Vessel

Tortugas was a Maltese-registered, 61,321 gt, roll on-roll off (ro-ro) vehicle carrier, built by Mitsubishi Heavy Industries Ltd., Japan, in 2006. The vessel was owned by Julia Shipping S.A. and managed by Wilhelmsen Ship Management (Norway) A.S. (the Company). Det Norske Veritas (DNV) acted as the classification society as well as the recognized organization, in terms of the International Safety Management Code, for the vessel.

Tortugas vessel had a length overall of 199.99 m, a moulded breadth of 32.26 m, and a moulded depth of 14.45 m. The vessel had a summer draught of 11.03 m, and a corresponding deadweight of 22,271 metric tonnes (mt). It had the capacity to load 6,564 cars on 12 tiers of car decks. The cargo units were loaded via stern and side ramps, and the vessel usually berthed with its starboard side alongside.

Propulsive power was provided by a 7-cylinder, slow-speed, two-stroke, Mitsubishi 7UEC60LSII marine diesel engine, producing 13,240 kW at 105 rpm. The vessel was also fitted with one 1,800 kW bow thruster.

Around the time of the occurrence, *Tortugas* was loaded with 1,123 mt (238 cargo units) of vehicles, drawing an even keel draught of 8.60 m.

1.2.1 The forward mooring deck

The forward mooring deck (**Figure 1**) was a sheltered deck, with cargo decks located above it (**Figure 2**). The mooring equipment on the forward mooring deck included two split-drum mooring winches on each side and two split-drum mooring winches in the centre. The bosun recalled that the forward mooring deck was quite noisy during mooring operations, due to the bow thruster’s motor.

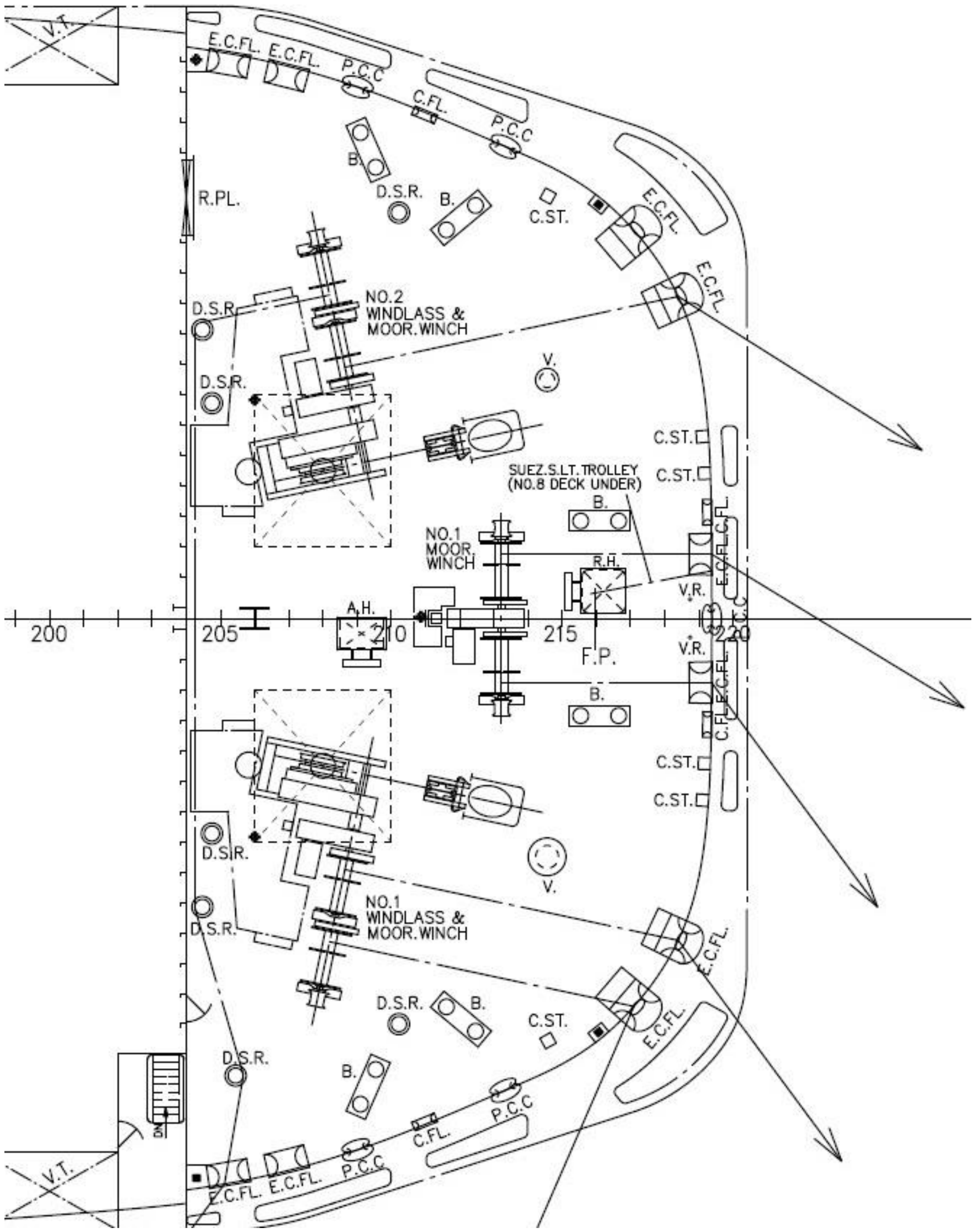

Figure 1: Layout of the forward mooring deck

Figure 2: The location of the forward mooring deck (highlighted in red), as seen from outside

1.2.2 Mooring winches

All mooring winches on board *Tortugas* were electrically driven. On the forward mooring deck, the port and starboard side mooring winches shared the same motor as the port and starboard windlasses, respectively. The mooring winches could be operated locally, as well as from remote control stands.

The crew members did not report any problems with any of the winches. In accordance with the vessel's planned maintenance system (PMS) records, the last inspection and brake rendering test of all mooring winches was carried out on 30 August 2022, with no problems noted. This was a six-monthly routine procedure on board *Tortugas*.

1.3 Crew

Tortugas' Minimum Safe Manning Certificate stipulated a crew of 15[1]. The vessel was manned by 23 crew members, including two third officers. 12 crew members were Indian nationals, while the rest were Filipino nationals. The working language on board was English.

At the time of the occurrence, the forward mooring station was manned by four crew members: one third officer, the bosun, an ordinary seafarer (OS) and the deck cadet.

The seriously injured third officer was a 25-year-old Indian national. He had about four years of seafaring experience, all of which were served with the Company, and he had previously served as a deck cadet[2] on board *Tortugas*. He held STCW[3] II/1 qualifications for an officer in charge of a navigational watch, and his certificate of competence was issued by the Directorate General of Shipping, India, on 28 June 2022. This was his first employment term as a third officer. He had joined the vessel on 13 December 2022, at the port of Santos, Brazil. He had supervised 10 mooring operations, prior to the occurrence.

The bosun was a 57-year-old Filipino national. He had about 31 years of seafaring experience, 26 of which were served with the Company. His 18 years of experience as a bosun were all served in the Company. He held STCW II/4 qualifications for a rating forming part of a navigational watch, and his certificate of proficiency was issued by the Maritime Industry Authority of the Philippines (MARINA), on 18 February 2015. He had joined *Tortugas* on 17 January 2023, at the port of Baltimore, USA.

The OS was a 27-year-old Filipino national. He had seven years of seafaring experience, about 3.5 of which were served with the Company. His two years of experience as an OS were all served with the Company. He held STCW II/4 qualifications for a rating forming part of a navigational watch, and his certificate of

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1 Provided that the unmanned machinery space (UMS) and the bridge control systems were operational, and at least two deck officers held Global Maritime Distress and Safety System (GMDSS) General Operator's Certificates.

2 He had served for nine months, in 2018 / 2019.

3 IMO. (2020). *International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978* (Consolidated ed.). London: Author.

proficiency was issued by MARINA on 06 June 2017. He, too, had joined *Tortugas* on 17 January 2023.

The deck cadet was a 19-year-old Indian national. This was his first seafaring employment term. He held the basic STCW VI/1 training qualifications and had joined *Tortugas* on 11 December 2022.

1.4 Environment

At the time of the accident, the sky was clear, and the visibility was about 10 nautical miles (nm). Winds of Beaufort Force 7-8 were blowing from the West, and the sea state was 'moderate', with a low, Westerly swell. The air and sea temperatures were recorded as 8 °C and 6 °C, respectively.

1.5 Narrative

Tortugas arrived at the Teesport pilot station at about 0600, on 30 January 2023. Two pilots boarded the vessel at 0624. Following a master / pilot exchange of information, the master held a toolbox talk on the bridge, where he briefed the two third officers, who were responsible for the forward and aft mooring stations, about the tugboat and mooring configuration[4]. The officers were informed that the vessel would be moored with three head and stern lines, with the head and stern lines being sent ashore via mooring boats, one spring line each, forward and aft, and a breast line each, forward and aft.

On reaching their respective mooring stations, the third officers discussed the plan with the crew members there. Shortly after, *Tortugas* entered the approach channel to the port. At 0705, two tugboats were made fast, one forward and one aft. A third tugboat stood by, to assist on the vessel's port beam. Eventually, the vessel entered the basin to come alongside its designated berth.

At 0730, the forward mooring station team passed the first mooring line ashore, which was the forward spring line from the outer split-drum of the starboard mooring winch.

[4] The master, chief officer and both third officers were present for the toolbox talk. The second officer was resting in his cabin.

At 0735, due to a strong offshore wind, the forward tugboat was cast off and was requested to push *Tortugas* from the port side midship area, to help keep the vessel alongside the berth. Meanwhile the aft mooring station team passed the aft spring line ashore. One breast line each were then passed from the forward and aft mooring stations, with the forward breast line[5] being passed from the inner split-drum of the starboard side mooring winch (**Figure 3**).

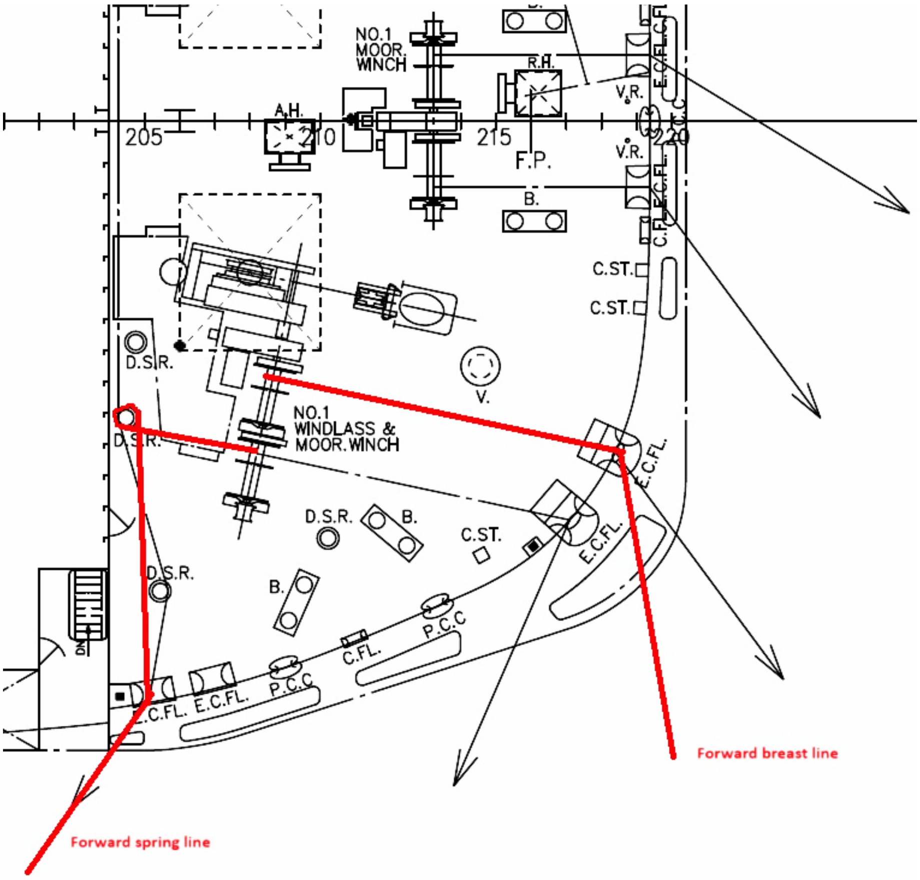

Figure 3: The forward mooring configuration after one spring line and one breast line were passed

At 0744, the bridge team decided that due to the strong offshore wind, an additional breast line would have to passed from both mooring stations. The message was conveyed to the forward and aft mooring station teams. A minute later, the pilot advised the master, that the vessel would have to move about 10 m ahead, so that the ramp could be correctly positioned. It was agreed that this movement would be done, using the vessel's spring lines, with the tugboats assisting, and the main engine used as required.

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5 The third officer informed the safety investigation that the forward breast line was leading almost perpendicular to the length of the vessel, when it was made fast.

The mooring station teams were informed about this movement and were advised to stand by to adjust the mooring lines, so that the vessel could move ahead[6]. While the aft mooring station team confirmed their readiness for the movement, the forward mooring station team requested some more time to prepare[7].

At 0747, the third officer at the forward mooring station confirmed his team's readiness to the bridge. The master then instructed the crew members to slack the forward spring line and heave up the aft spring line. The officers of both mooring stations acknowledged these instructions. The main engine was then ordered to 'dead slow ahead', following the pilot's advice, and the vessel started to move ahead.

At 0748, when the vessel had moved about 6.0 m, the master observed the forward spring line getting taut and the forward breast line getting slack. He instructed the forward mooring station team not to slacken the breast line. A few seconds later, however, the forward spring line parted with a loud noise. The mooring winch brake did not render.

The main engine was immediately stopped, reversed, and followed with a kick astern. The master then called the forward mooring station team to check if all was well. The bosun immediately replied on his portable radio, that the third officer had been injured.

The chief officer rushed froward with a medical team to assess the third officer's condition. The injured third officer was observed to be in pain; although there was no bleeding, it appeared that he had suffered a fracture of his right thigh bone. The medical team immobilised the third officer's right leg and shifted him on a stretcher, to a nearby sheltered location.

Meanwhile, the pilot notified the local authorities about the accident, and requested for a shore ambulance. The master notified the Company and the vessel's local agents.

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[6] For this movement, the forward spring line had to be slackened while the aft spring line had to be heaved in. Also, the breast lines had to be kept in check until the vessel was in position.

[7] The bosun informed the safety investigation that although he was carrying a portable radio, he had turned its volume low to prevent static interference with the third officer's radio communication, which would tend to occur particularly when they were in close proximity to each other. He, therefore, only became aware of the instruction for shifting ahead, through the third officer.

The rest of the crew members completed the mooring operation and at 0842, the stern ramp was lowered to allow the shore ambulance to reach the injured third officer's location. Medics from the shore ambulance assessed the injured third officer's condition before transferring him to a local hospital.

1.6 Reported Injuries

At the shore hospital, it was confirmed that the third officer had a suffered a fracture of his right femur. On 04 February, following a surgical intervention, the third officer was discharged from the hospital. He remained in the UK for treatment until he fully recovered from his injuries before he was repatriated.

1.6.1 Records of Hours of Work / Rest

According to the vessel's records, the injured third officer's hours of work / rest for the month of January 2023, met the STCW Convention requirements. The day before the occurrence, he had worked from 0600 till 1200 and then from 2000 till 2400. On the day of the occurrence, he had reported for duty at 0530.

1.7 Location of the Crew Members at the Time of the Occurrence

At the time of the occurrence, the third officer was standing aft of the forward spring line, which he was monitoring (**Figure 4**).

Figure 4: Reconstruction of the position of the third officer when he was monitoring the forward spring, before it parted

The bosun, OS and deck cadet were at the forward region of the mooring deck, preparing to pass an additional breast line (**Figure 5**). The forward spring and breast lines were held by the mooring winch brakes and their gears had been disengaged. None of the crew members were tending to these mooring winches[8].

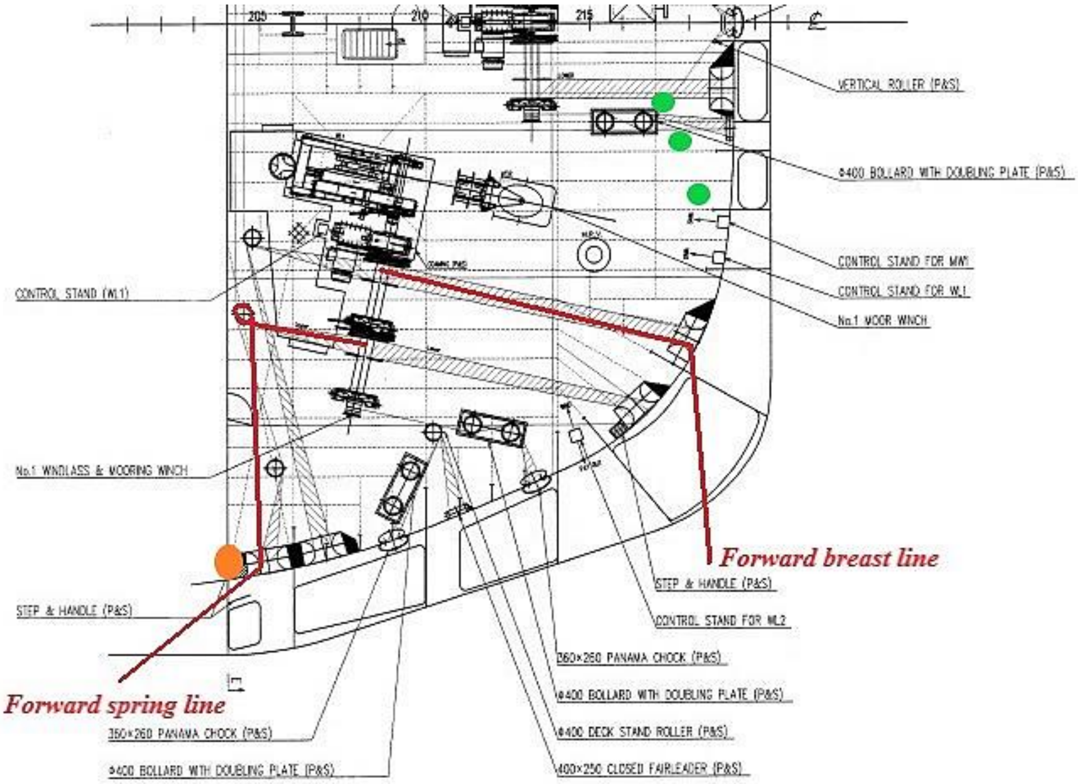

Figure 5: Approximate reported locations of the crew members at the time of the occurrence (orange dot: the third officer; green dots: the bosun, OS and deck cadet)

Just before the rope parted, the third officer had turned to face the mooring winch. It was at that time that the parted rope struck him on his right thigh. The other crew members at the forward mooring station recalled hearing the spring line stretch. However, they stated that the rope parted within seconds of them hearing the stretching sounds.

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[8] Whilst the seriously injured third officer informed the safety investigation that the bosun was tending to the mooring winch from the forward remote-control stand, the Company's follow-up with all the crew members revealed that the OS on the mooring deck (topmost green circle in **Figure 5**) had turned around and started moving towards the control stand, and started moving towards it, when he heard the crackling noises from the mooring line.

1.8 The Parted Mooring Rope

The mooring rope that parted (**Figure 6**) was a 12-strand, high performance polyester mooring rope. The mooring rope's certificate stated that it had a diameter of 56 mm, a length of 220 m, and a breaking load of 611 kN.

Figure 6: The forward spring line that parted

The vessel's PMS required the mooring ropes to be inspected every three months. All mooring ropes, including the one which parted, had last been inspected by the chief officer on 17 December 2022. Their condition was noted as satisfactory[9].

9 The safety investigation also observed that during the mooring ropes' inspection in September 2022, the condition of the forward spring line that parted was recorded as fair. That inspection was carried out by a different chief officer.

The mooring rope had parted about 63 m from its free end, and about a metre from the mooring winch *i.e.*, between the mooring winch and the pedestal fairlead around which it was passed (**Figure 7**).

During the safety investigation's visit on board, however, several damages were observed along the length of the mooring rope (**Figures 8a** to **8c**), other than the point of failure (**Figure 9**).

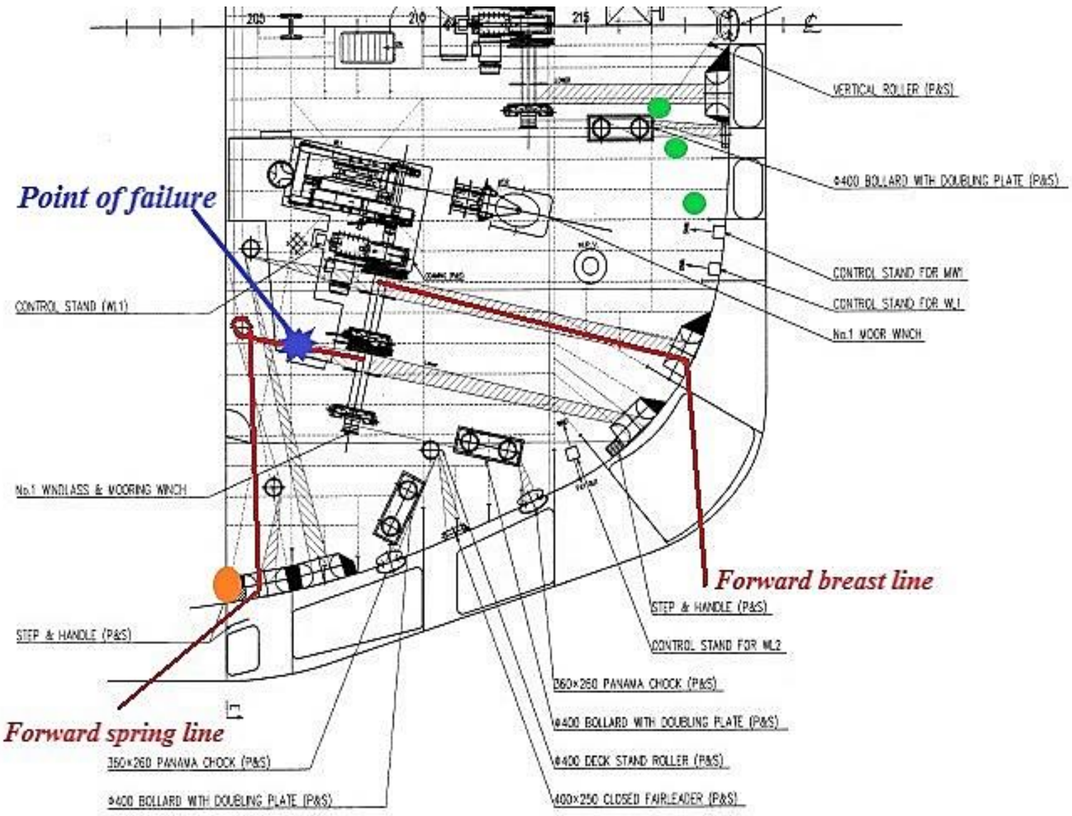


Figure 7: The point of failure of the forward spring line

Figures 8a to 8c: Other observed damages

Figure 9: The point of failure

1.9 Port State Control Inspection

Following the occurrence, a port State control officer (PSCO) boarded the vessel at Teesport. The PSCO instructed the vessel to replace three other mooring ropes on the forward mooring station.

2 ANALYSIS

2.1 Purpose

The purpose of a marine safety investigation is to determine the circumstances and safety factors of the accident as a basis for making recommendations, to prevent further marine casualties or incidents from occurring in the future.

2.2 Safety Investigation Actions

Immediately after being notified of the occurrence, the MSIU requested the Company to preserve all relevant data. Due to the vessel's itinerary, the MSIU's representative could only board the vessel on 04 February, at Bremerhaven, Germany, which was the vessel's next port of call.

The MSIU requested the Company to ship two samples (A and B) of the parted mooring rope to Malta. Each sample was about 2.0 m long and were taken from either side of the point of failure (**Figure 10**).

The rope samples arrived at the MSIU's office on 25 April, following which, they were sent to an independent, accredited laboratory for non-destructive tests.

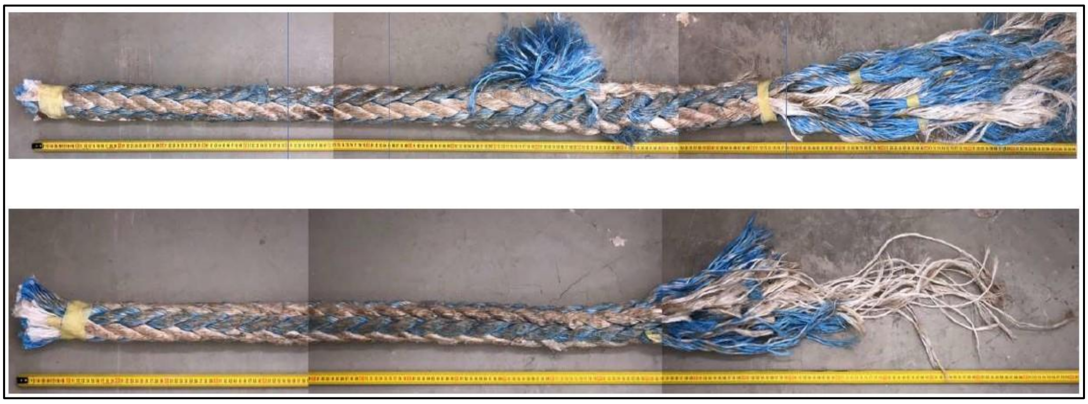


Figure 10: The rope samples (right: sample A; left: sample B)

2.3 Mooring Rope

2.3.1 Mooring rope diameter

During the inspection of the samples of the failed mooring rope at the laboratory, the rope's diameter was measured as 63 mm. On enquiring with the rope manufacturers, through the Company, the safety investigation was advised that mooring rope diameters are given as a nominal value, and the actual measured diameter of a mooring rope would be expected to be much higher than the diameter mentioned on the rope's certificate[10]. For instance, the actual measured diameter of a 54 mm rope could be almost 69.5 mm, depending on, inter alia, the rope's use.

2.3.2 Laboratory inspection of the samples

Sample A was inspected in three segments. The visual inspection of the first segment (furthest away from the point of failure) showed signs of fraying and abrasion along the length of this section. A number of cut fibres were observed at a distance away from the point of failure (**Figure 11**).

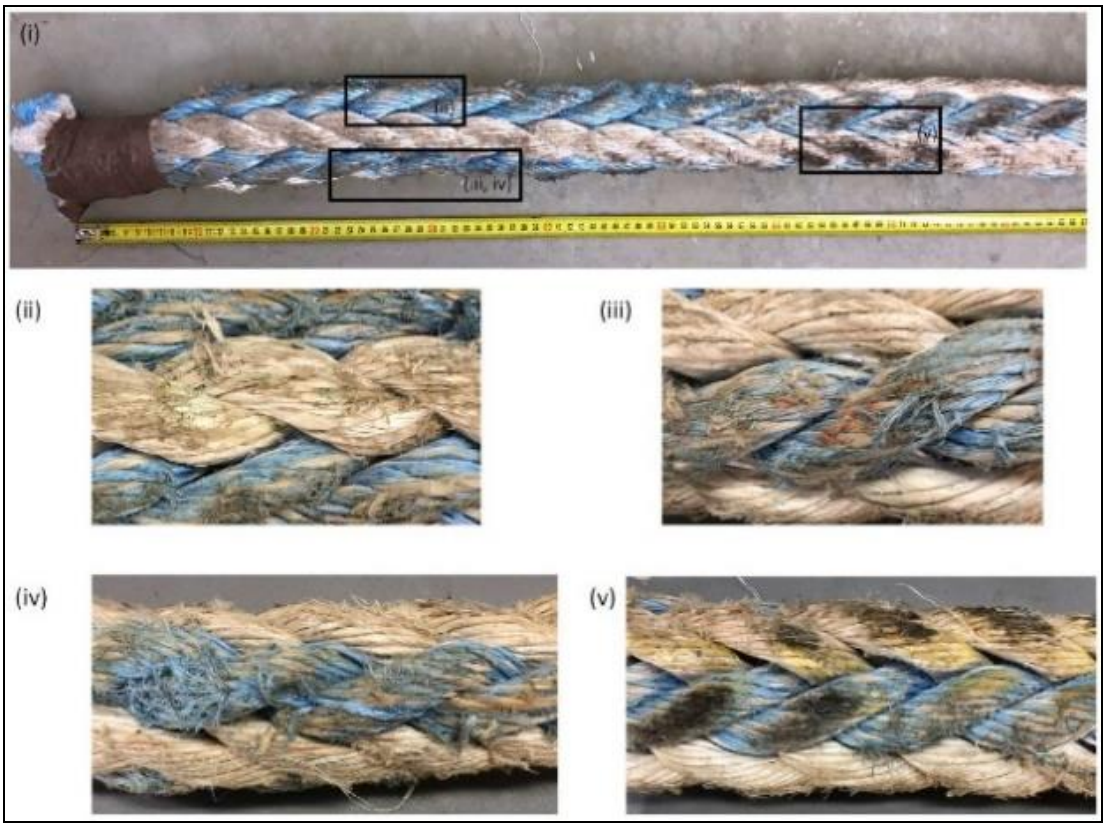


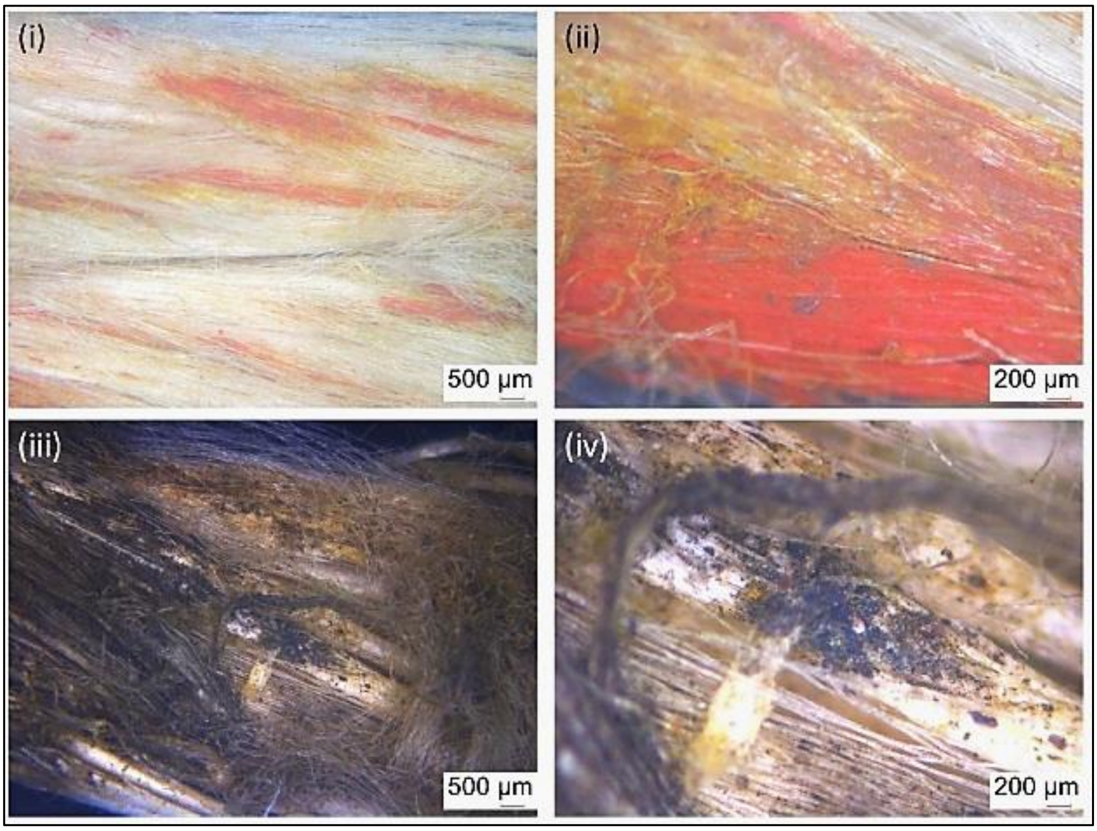
Figure 11: Damages on the first segment of sample A

[10] *Vide* Caradec, T. (2022). *Selecting the right rope - why should you be looking at LDBF?* Wilhelmsen. Retrieved 03 October from https://www.wilhelmsen.com/ships-service/ropes/selecting-the-right-rope/

Along the length of this sample, the damages were visible only on the surface and not on the inside / in between the strands. Powdered fibre (an indication of internal wear) was not observed. Additionally, several red, black, and yellow stains were observed.

Microscopic imaging was then carried out, using an Optiphot-100 optical microscope and a Nikon SMZ-2T stereomicroscope equipped with a Leica DFC 290HD fast-acquisition digital camera[11].

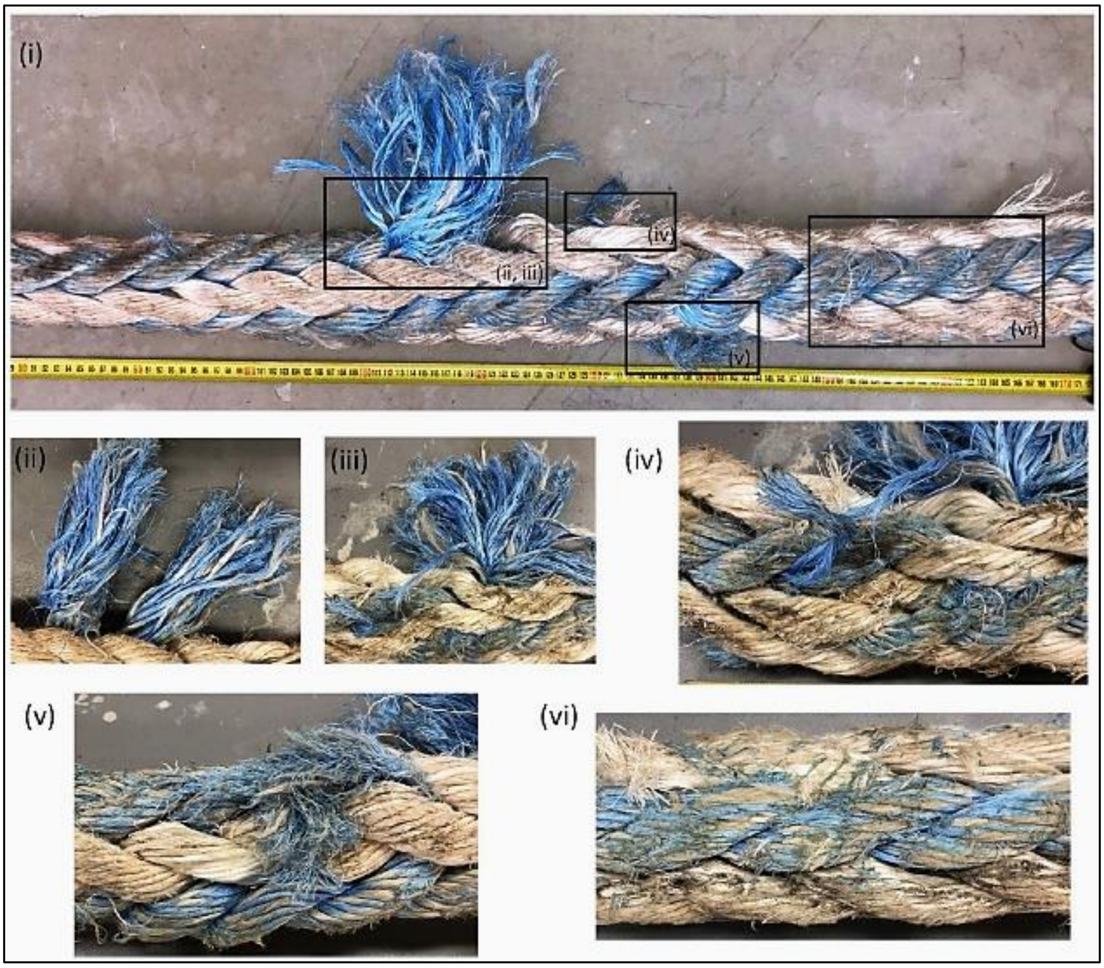
The region of staining was studied using optical microscopy (**Figures 12(i)** to **12(iv)**). The reddish traces seen in **Figures 12(i)** and **12(ii)**, were attributed to the rope rubbing against the painted surfaces of mooring fittings. Localised red spots were also noticed and these, too, were observed to be due to paint transfer. There were no signs of adhesion of ferrous corrosion (traces of rust). The black stains appeared to be localised regions which were exposed to heat build-up, and dirt and grime, caused by friction, the rubbing of yarns on other yarns and against metallic surfaces.



Figures 12(i) to 12(iv): Stereomicrographs of the regions of staining on sample A

[11] For this imaging work, small rope segments / fibres were cut, when required, to allow manipulation or expose area of interest within the rope's core.

A higher degree of degradation was observed in the second (middle) segment *i.e.*, closer to the point of failure (**Figures 13(i)** to **13(vi)**). The surface damage was more pronounced, but more importantly, large strand failure was prominent. The parted strands showed little to no degradation near the ends of the fibres (**Figure 13(ii)**, **(iii)** and **13(iv)**), indicating that these fibres had most likely failed during the same event.



Figures 13(i) to 13(vi): Damages on the second segment of sample A

Conversely, the morphology of the fibres seen in **Figure 13(v)** suggested that these may have parted during a previous mooring operation. The failed strands showed signs of abrasion and soiling, thus indicating continued use after this localised and relatively minor failure event. Such minor failure may have been caused by routine operation at loads closer to the breaking load of the rope, coupled with accumulated fatigue damage. The failed ends of these fibres would have been located in the interior region of the rope and would, therefore, rarely experience any wear against metallic surfaces.

On the parted end of the rope sample (third segment), too, abrasion was not observed on the inside surfaces (**Figure 14**). The exposed interior surfaces of the strands did not show major signs of twisting which would have allowed rubbing of internal surfaces. Thus, wear damage was mostly limited to the periphery of the strands, depending on the twist of the specific strand. There were minor exceptions, such as fibres which were visibly more deteriorated than the surrounding parted strands, which again suggested failure predating the final catastrophic event.

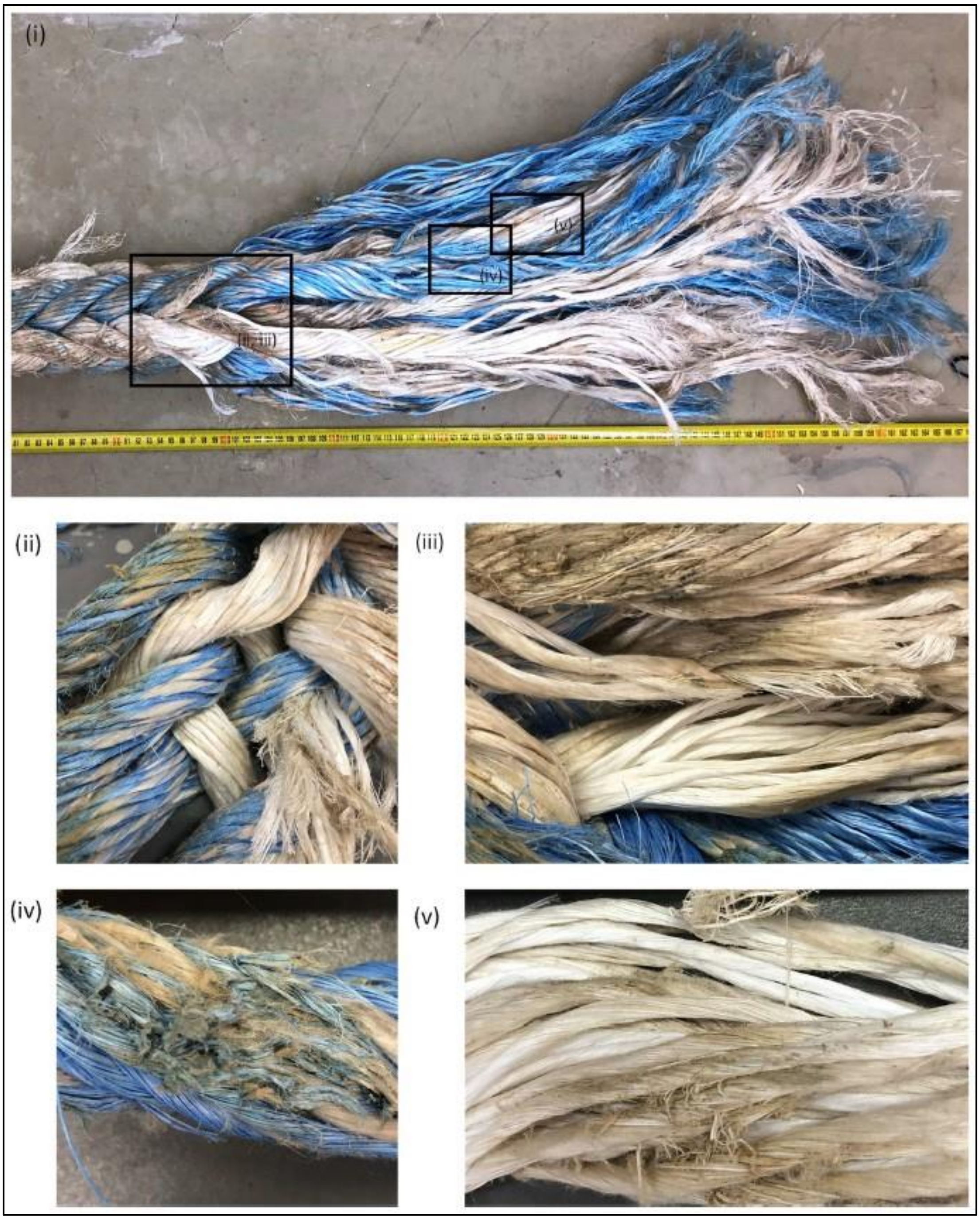


Figure 14: Damages on the third segment (point of failure) of sample A

Sample B broadly exhibited the same types of damages as sample A, including signs of abrasion and superficial broken fibres (**Figures 15** and **16**).

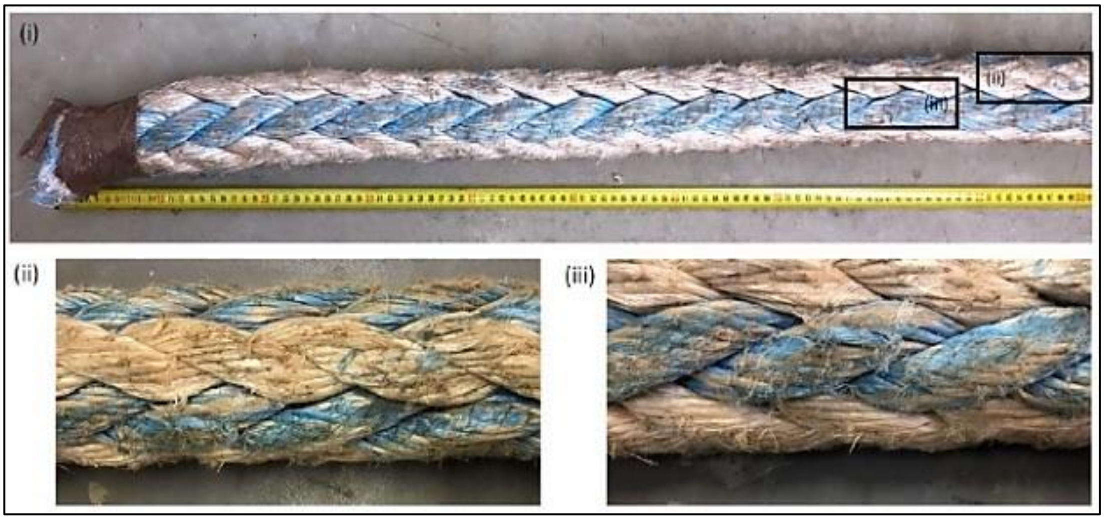


Figure 15: Damages on the first segment (furthest away from the point of failure) of sample B

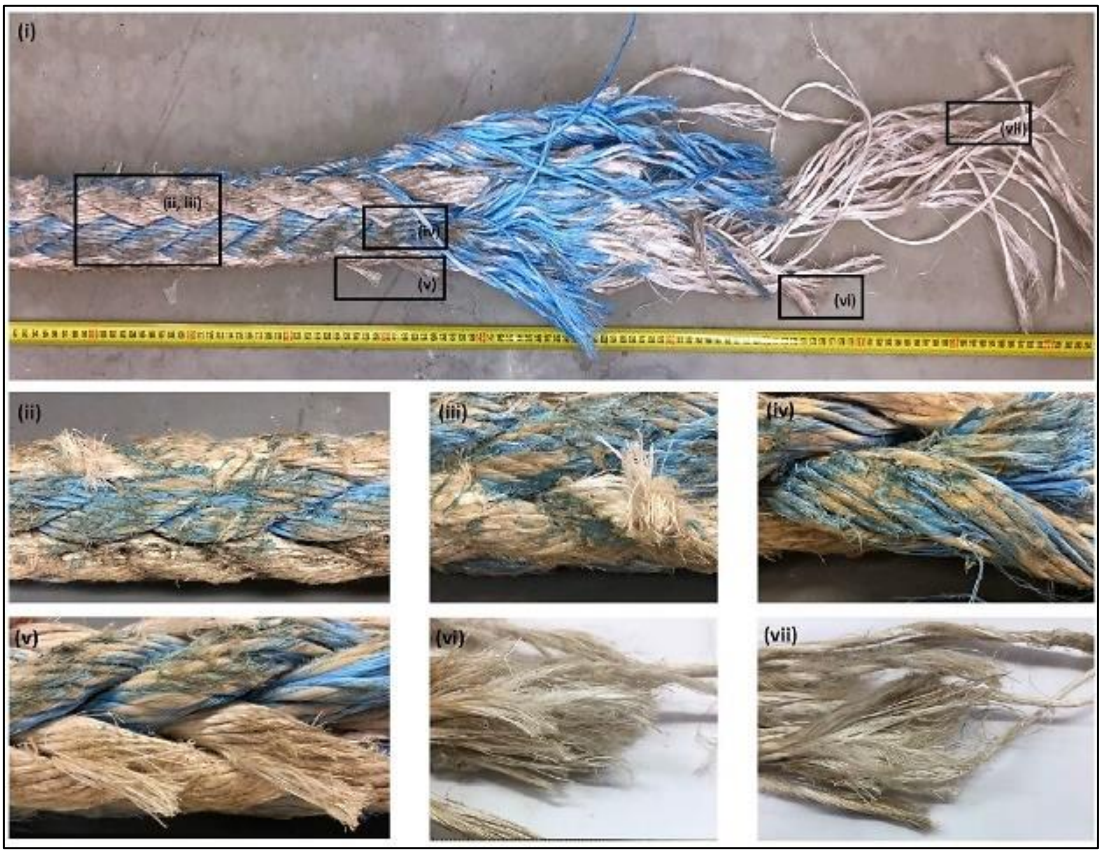


Figure 16: Damages on the third segment (point of failure) of sample B

2.3.3 Failure analysis

The general extent of reduction in strength of the rope could not be accurately determined. However, the limited extent of fibre abrasion damage, together with the 12-strand construction of the rope, suggested that the net impact on the overall residual strength was limited, albeit not insignificant (< 10%).

Cross-sectional imaging provided a visual of the generally unblemished condition of the bulk material of the rope (**Figure 17**). This, however, did not take into account more significant localised damage, such as wear confined to smaller sections of strands, and pulled out or cut fibres, which may have had an important contribution in the reduction in residual strength of the rope.

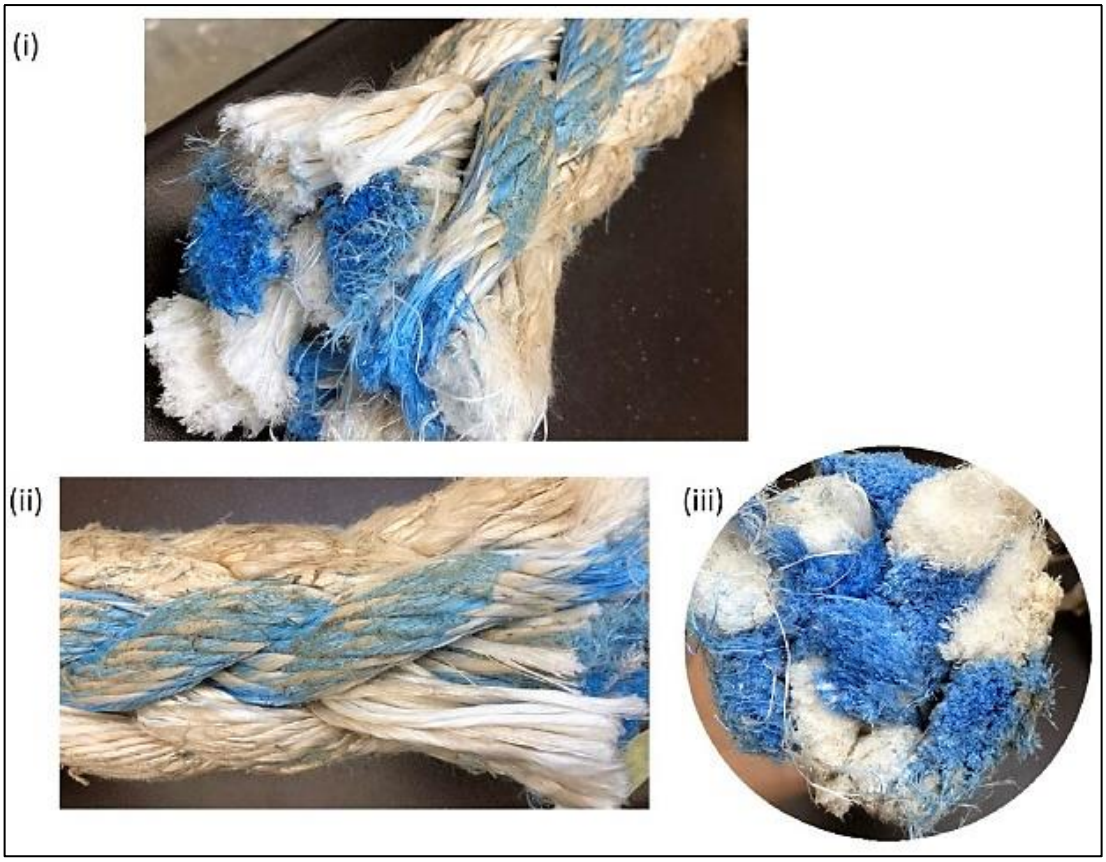
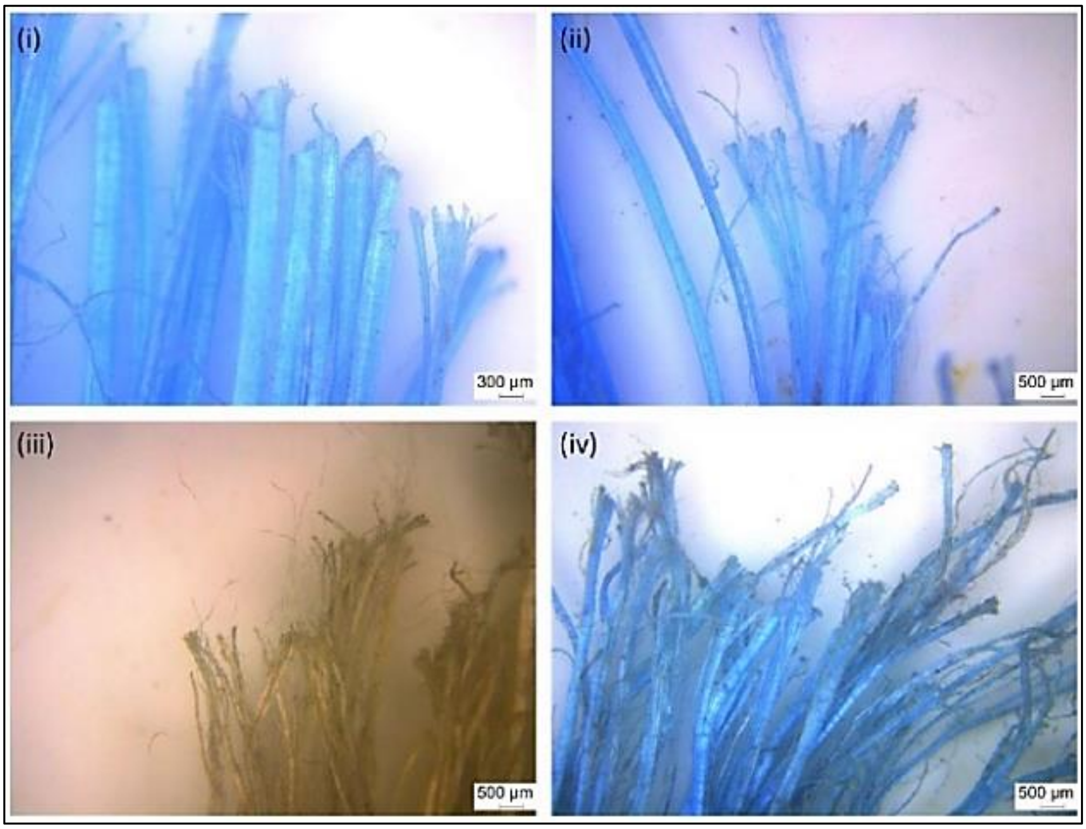


Figure 17: Cross-sectional images of a cut sample

Stereomicroscopic imaging of several fibres extracted from the failure region of both samples (**Figures 18(i)** to **18(iv)**), indicated that the morphology of the fractured ends exhibited by these fibres, whether extracted from the interior sections of the rope (**Figures 18(i)** and **18(ii)**) or from its exterior region, largely conformed to the anticipated characteristics of tensile-overload failure.



Figures 18(i) to 18(iv): Stereomicrographs of the parted fibres

In these cases, the initiation of the failure was often on the same surface as the transverse ultimate fracture surface. In a few cases, certain fibres displayed signs of fatigue. These particular fibres exhibited a longer propagation crack running along the length of the fibre axis, resulting in a distinct protrusion ahead of the region where the catastrophic failure ultimately occurred. Furthermore, in the case of exterior fibres, noticeable abrasive damage was also observed.

Based on the above, the safety investigation concluded that the mooring rope had failed due to tensile overload. The broken fibres and yarns had most probably lowered the rope's residual breaking load, thus making it susceptible to overload caused by dynamic loading conditions on the rope. The dynamic loading conditions would have been experienced due to, inter alia, the mooring equipment, effects of ship acceleration inertia, wind gusts, while the vessel was moored. Furthermore, similar past high load events may have caused creep damage, which would have significantly lowered the rope's maximum breaking stress prior to tensile failure.

The probable reduction in the rope's residual breaking load would explain why the mooring winch brake did not render.

2.4 Mooring Decks

2.4.1 On-board inspections of the mooring rope

To predict the failure of a mooring rope, samples of the rope would have to be regularly tested and analysed ashore, during their lifetime. Crew members on board are not provided with the necessary training and equipment to carry out such tests and analyses. Therefore, whilst a visual inspection of a mooring rope by a crew member is more likely, it cannot be expected to be intensive enough to effectively determine whether the rope is suitable for further mooring operations or not. Furthermore, if a spare mooring rope is not available on board, the crew members would have no choice but to potentially continue using a rope that in their view was not safe for use anymore[12].

Moreover, visual inspections of mooring ropes by crew members may tend to be subjective. For instance, the condition of the mooring ropes was noted as satisfactory by the chief officer, in December 2022 while after the occurrence, the PSCO observed that three additional mooring ropes at the forward station, had to be replaced.

2.4.2 Maintenance of the mooring equipment

During the visit on board, the safety investigation noticed that the mooring equipment was well maintained by the crew members.

Furthermore, during the laboratory inspection, no of signs of adhesion of ferrous corrosion were observed on the parted mooring rope samples. This also indicated that the mooring equipment was well maintained and that hard ferrous oxide particles were not responsible for the damage of the mooring rope.

[12] It may not always be possible for a Company to supply a new mooring rope to the vessel, in time. The sourcing, availability, and logistics involved might not allow for a quick delivery. This would be further complicated if the vessel has a short turnaround time or operates in remote locations.

2.5 Readiness for Shifting of the Vessel Ahead

The third officer had confirmed the readiness of the forward mooring team for the intended shift of the vessel ahead. However, data indicated that the rest of the mooring team were busy preparing a second breast line to be passed ashore, whilst the third officer was monitoring the forward spring line. Neither the third officer nor any of the other crew members had gone to the starboard mooring winches to loosen the brake and engage the gear of the forward spring line. In this regard, it did not appear to the safety investigation that the forward mooring team was actually ready for the shifting.

The safety investigation considered it likely that the third officer may have requested the bosun to tend to the mooring winch operation, for the shifting. However, due to the noise from the bow thruster engine, the bosun may not have heard this request.

2.5.1 Location of the third officer

The safety investigation tool note that the vessel was fitted with pedestals to observe the mooring lines overside. One pedestal was located close to the site of the occurrence (**Figure 19**).

Figure 19: The starboard side pedestal

The seriously injured third officer, however, informed the safety investigation that he was not comfortable using this pedestal, fearing that he could fall overboard, since he felt that using it would require him to lean overside too much to get a proper view of the spring line.

2.5.2 Internal communication

Effective communication between the bridge and the mooring team as well as among members of the mooring team, is key to a safe and quick mooring operation. Whilst the use of portable radios assists in communication, it requires frequent exchange of information between the bridge and the mooring teams, especially since the bridge team may not always have a clear view of the mooring teams' actions[13]. Thus, the officer supervising the mooring team would have the additional responsibility of communicating with the bridge.

At the mooring stations, members of the mooring team may be obscured from each other due to the presence of the mooring equipment, such as winches and pedestal fairleads. They would, therefore, be unable to use hand signal effectively to communicate. In cases, as was so at the forwarding mooring station on *Tortugas,* the loud sounds of engines, motors, *etc*., would even make verbal communication difficult.

Whilst in such cases, too, a portable radio would be useful, the need to lower the volume of the radio to prevent static interference would not help. The aforementioned factors could probably explain why the bosun and the other crew members were engaged with preparing to pass the second breast line, whilst the third officer believed that the bosun was tending to the mooring winch.

2.6 The Complexity of Mooring Operations

Mooring operations are a critical task on board. It is critical to have the vessel moored within a short period of time, in view of several factors. There are the financial aspects, due to, inter alia, the engagement of a pilot and tugboats. Then, there is also the more-critical, safety aspect, in view of tidal streams (in tidal ports) or

[13] In the case on board *Tortugas,* the crew members had no view of the forward mooring station at all.

currents, and winds. The longer a mooring operation takes, the longer the vessel will be exposed to such natural phenomena, and the mooring ropes which would have already been made fast, would thereby experience considerable strain. Additionally, a prolonged mooring operation would make it difficult to get the vessel into the required position and effectively moored for cargo operations to commence, *i.e.*, financial repercussions.

While a mooring operation is a routine task for all deck crew members, it is also a hazardous, and complex task[14]. The most readily identifiable hazard is the layout of a mooring deck, with all its equipment and fittings, that poses obstructions for crew members who are under pressure to complete the mooring operation quickly. Then, there are also the hazards of mooring equipment / fitting failure, which may be the result of wear and tear, and / or material fatigue.

One of the most common of causes of injuries during mooring operations, is the failure of a mooring rope. If a mooring rope under tension fails, it is practically impossible for crew members to predict the path of the parted sections of the rope. The entire mooring deck is, therefore, considered as a hazardous area, with the crew members constantly exposed to this hazard.

To have a mooring operation completed quickly, crew members have to be quick in their actions. To do so, crew members may at some point during a mooring operation, may need to juggle numerous, simultaneous tasks, their actions depending on their understanding of the situation at that time. This context is suggestive of the complexity on a mooring station and any accident which may happen, could potentially lead to severe consequences.

The added task of communication with the bridge (necessary as it may be) makes matters even more complex for the crew members at the mooring station. Instructions from the bridge or requests from for vital information (say, distance from a vessel ahead / astern, lead of the mooring lines that were sent ashore, *etc*.), are all instances which compete with other pressing tasks, for the crew members' attention.

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[14] Patriarca, R., & Bergström, J. (2017). Modelling complexity in everyday operations: functional resonance in maritime mooring at quay. *Cognition, Technology & Work, 19*(4), 711-729. https://doi.org/10.1007/s10111-017-0426-2

When crew members are exposed to unsafe positions on mooring stations, it could very well be a conscious decision to accept the risk, based, however, on the assumption that the ropes and other mooring equipment will not fail. Equally, it could be a situation where crew members unknowingly put themselves in such a position, particularly when they are extremely focussed on either executing instructions or addressing a query from the bridge. Here, again, a clear view of the mooring deck and communication are key, for if one crew member can see another putting themself in an unsafe position, they can advise them to move away from that position.

THE FOLLOWING CONCLUSIONS, SAFETY ACTIONS AND RECOMMENDATIONS SHALL IN NO CASE CREATE A PRESUMPTION OF BLAME OR LIABILITY. NEITHER ARE THEY BINDING NOR LISTED IN ANY ORDER OF PRIORITY.

3 CONCLUSIONS

Findings and safety factors are not listed in any order of priority.

3.1 Immediate Cause of the Accident

.1 The forward spring line parted whilst the vessel was shifting its position at berth, seriously injuring the third officer.

3.2 Conditions and other Safety Factors

.1 The forward spring line parted due to tensile overload.

.2 The rope's residual breaking load had most probably been lowered by previously broken fibres and yarns, thus making the rope susceptible to overload, caused by dynamic loading conditions.

.3 Past high load events may have caused creep damage, which would have significantly lowered the rope's maximum breaking stress prior to tensile failure.

.4 Although the crew members knew that the forward spring line had to be slackened for the vessel to move ahead, neither the third officer nor any of the other crew members had gone to the mooring winch to loosen the brake and engage the gear. This was indicative of a communication gap between the members of the forward mooring team.

.5 The seriously injured third officer had positioned himself in close proximity to the forward spring line and did not use the pedestal specifically fitted to observe the mooring ropes, since he felt that using it involved a risk of falling overboard.

.6 The condition of all mooring ropes was noted as satisfactory by the chief officer, in December 2022, while after the occurrence, the PSCO observed that three additional mooring ropes of the forward station needed to be replaced. This suggested that a visual inspection of mooring ropes by crew members, may tend to be subjective.

4 ACTIONS TAKEN

4.1 Safety Actions Taken During the Course of the Safety Investigation

Following its internal investigation of this occurrence, the Company took the following actions across its fleet:

i. reviewed and updated the section on mooring operations in its safety management manual (SSMM),

ii. implemented an electronic line management plan (LMP), which included guidance on the required documentation, and wear and tear identification,

iii. circulated the lessons learnt,

iv. introduced an awareness campaign on the human element of safe mooring, which addressed training (including e-learning and computer-based training modules), the SSMM requirements, and a vessel-specific risk assessment,

v. ensured that its vessels completed a thorough inspection of all mooring lines and documented details of the inspection either in the PMS or LMP[15],

vi. verified the fleet's status of replacement of old mooring ropes with snap-back arrestor-type mooring ropes, and several mooring ropes have been replaced across the fleet, and

vii. ensured that its vessels had set up tasks for mooring winches, their brakes, mooring lines, and other associated tasks / inspections, in the PMS.

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[15] The Company has confirmed that all vessels in the Group have implemented the LMP. Through this system, vessels ensure that three-monthly jobs are carried out in due time, whilst maintenance, use, and inspection history are also made readily available. The LMP enables users' feedback on pictures, which are being uploaded. The use of LMP for the mooring line inspections also ensures that either previously reported damage, or areas of concerns are highlighted for the next person completing the inspections (through traceable history on each individual line, with registered details on previous damages / areas for additional follow up).

5 RECOMMENDATIONS

In view of the safety actions taken by the Company during the course of the safety investigation, no safety recommendations have been made.