DMAIB
DANISH MARITIME ACCIDENT INVESTIGATION BOARD

TORM MAREN

Marine accident report on loss of rescue boat

1 APRIL 2020

MARINE ACCIDENT REPORT ON LOSS OF RESCUE BOAT ON TORM MAREN ON 1 APRIL 2020

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Photo: Fractured wire rope
Source: DMAIB

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

Content

Summary

In the morning of 2 April 2020, DMAIB was notified about an accident that had occurred on TORM MAREN the previous afternoon, while the ship was adrift, approx. 115 nm off the coast of Guinea. The rescue boat had fallen into the sea from deck level with three crewmembers on board. All three crewmembers suffered serious injuries.

The accident was considered serious due to the severity of the crew's injuries caused by a failure of safety critical equipment. Consequently, a full investigation was launched.

During the preliminary investigation it was found that the wire lifting rope was severely corroded which caused it to part during retrieval of the rescue boat. The corroded wire rope was, however, part of a larger system comprising mechanical components, planned maintenance system, regulation, safety management system and training regimes. The parting of the wire rope was thus not the cause of the accident in itself, but an accident event which required an investigation of the circumstances leading to the deterioration of the wire rope.

Even though the company's planned maintenance system and the manufacturer's manual instructed the officers to inspect and maintain the wire rope, they did not act upon the deteriorating condition of the wire rope. Neither did any of the other officers who continuously inspected, maintained and operated the rescue boat system even when the wire rope was readily visible.

The reason why the condition of the wire rope was not recognised as being detrimental to the functioning of the rescue boat system was found to be a combination of three factors: Firstly, the manufacturer's manual and PMS which did not specify how to assess the condition of the wire rope. Secondly, an absence of training in assessing the wire rope's condition. Thirdly, the PMS activities were compartmentalised which in practise meant that only one person was assessing each component. Additionally, all the factors were compounded by the thorough examination performed by service providers which made the officers trust not only the load bearing capability of the wire rope, but the man-riding capability of the system as a whole.

Narrative

Reconstruction of the course of events

The description of the course of events covers a period from TORM MAREN approached a position approx. 115 nm from Guinea in the early afternoon of 1 April 2020, until the injured crew members were disembarked at Conakry anchorage, Guinea, in the morning of 2 April 2020.

The reconstruction of the course of events was based on interviews with a selected group of crew members, VDR recordings, log book records and photos taken before and after the accident. The narrative aims to describe the events from the perspective of the involved persons to give insights to how the events were perceived before the accident became evident.

Background

TORM MAREN (figure 1) was a crude oil/products tanker in worldwide trade manned with 18 crewmembers of mixed nationalities. During March 2020, TORM MAREN had been engaged in ship-to-ship (STS) operations off West Africa in Nigerian, Guinean and Togolese waters. These areas were considered to be high risk areas for piracy attacks and consequently all boat drills were postponed for when the ship had left the areas. By the end of March, the STS operations in waters off Togo were concluded, and while TORM MAREN was en route to Gibraltar for orders, the preventive measures against piracy were removed, including razor wire from the deck areas. As all boat drills were overdue, the master had planned to stop the ship and carry out the drills on 1 April 2020 while the ship was adrift approximately 115 nm off the coast of Guinea (figure 2).

Figure 1: TORM MAREN
Source: TORM A/S

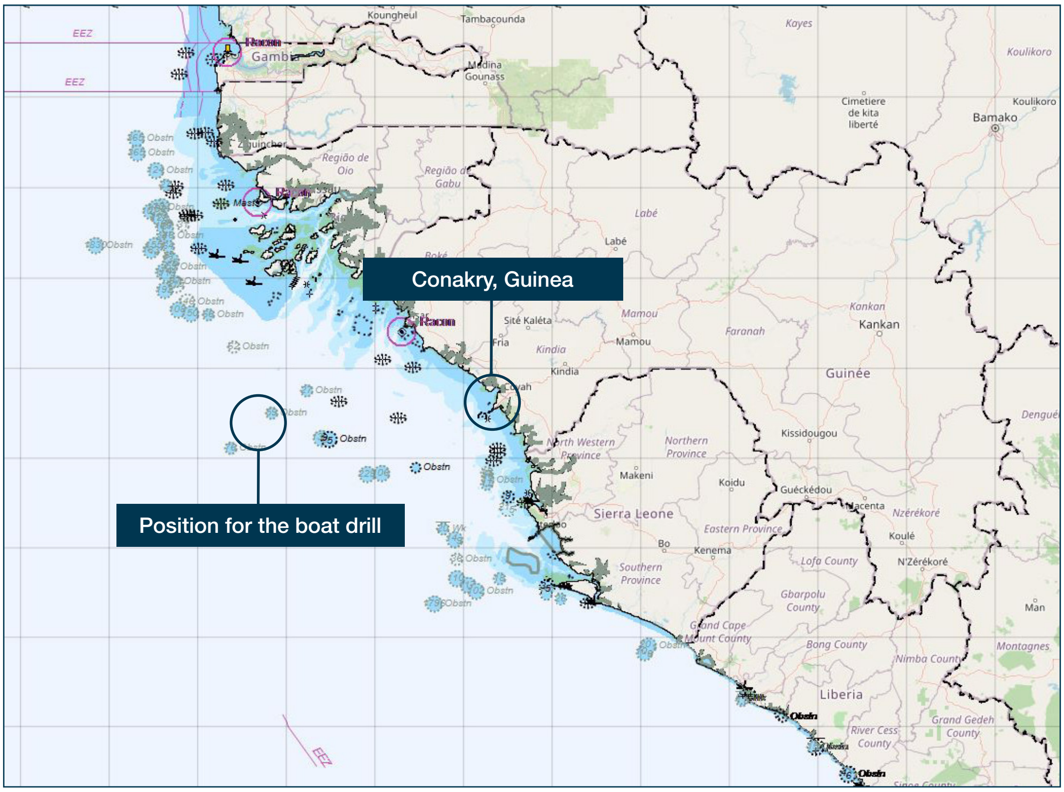

Figure 2: TORM MAREN's position for the boat drill on 1 April 2020
Source: Made Smart Group BV 2020; © C-Map Norway AS 2020 © Open Street Map contributers/ DMAIB

Course of events

The accident

In the early afternoon of 1 April 2020, the crew on TORM MAREN was about to carry out the boat drills. There was a gentle breeze from WNW, and the sea was calm. The 2nd officer had just taken over the watch on the bridge, and he slowly reduced the ship's speed, bringing the ship to stop. Meanwhile, the master came to the bridge, and they conversed about the weather and traffic in the area. Shortly after, the master left the bridge, and the 2nd officer went to the bridge wing to observe the launching of the lifeboats and the rescue boat. On the boat deck the crew gathered and prepared the boats. The lashings were removed, and the painter lines were prepared. The plan was to lower the lifeboats to the water one at the time with the 2nd engineer on board, and once waterborne the 2nd engineer would perform a test of the engines without disconnecting the boats from the hooks. Once the lifeboats had been tested, the 2nd engineer was to assist in the rescue boat drill.

While the lifeboats were tested, the rescue boat was launched and maneuvred close to the ship by a crew comprising the 4th engineer, 3rd officer and an AB. The chief officer operated the rescue boat crane, and an AB handled the painter line. The designated crew entered the boat, and it was swung outboards. The brake was disengaged, and the boat was launched. The boat crew maneuvred around the ship for half an hour, familiarising themselves with the boat and testing its maneuvrability. It was planned that the chief engineer and cadet would embark the boat afterwards, so the chief engineer could perform a visual inspection of the hull, and the cadet could maneuvre the boat to gain experience in boat maneuvring. As the ship was in ballast, the combination ladder was rigged, and the chief engineer and cadet embarked the boat, changing places with the 4th engineer and the AB while the rescue boat was in the water. The rescue boat was now manned by the 3rd officer, the chief engineer and the cadet.

They circled the ship for about an hour, and the chief engineer documented the condition of the hull, before they decided to bring the boat alongside and hoist it on board while the crew were in the boat. The cadet maneuvred the boat under the wire rope and hook, and the chief engineer connected the hook to the boat. Once the hook and painter line were fastened, the 2nd engineer immediately started to hoist the boat while the crew in the boat sat on the floor, so they would not fall over board during hoisting.

When the boat reached the boat deck, the 2nd engineer stopped the winch. Suddenly, the wire broke, and the boat fell 17 meters, and hit the water upright (figure 3). The engine was torn off its foundation, the bottom hull cracked, and it slowly drifted alongside the ship's port side with all three crew members still in the boat, but seriously injured. The 2nd engineer and 4th engineer, who stood by the crane, witnessed the boat fall and immediately called out for help. The time was 1537.

Figure 3: Height from where the boat fell
Source: TORM A/S

Emergency response

The master was in the duty mess with the chief officer when they heard noise from the deck and hurried to the boat deck. Once they realised what had happened, the master called the bridge, and told the 2nd officer to sound the man-over-board alarm before he went to the bridge and took command. On deck the chief officer took charge, and the officers had a short discussion about how to retrieve the injured crew and rescue boat. They decided that the best option was to use the main deck crane to hoist the boat back on board with the crew inside.

However, they had to resolve the immediate problem of how to bring the drifting rescue boat to the deck crane amidships. It seemed that the only option was to have a crew-member jump into the sea and swim to the rescue boat to retrieve the painter line which had been lost over board when the wire broke. The 3rd engineer volunteered to don a life jacket, climb down the combination ladder and swim to the boat. Once the painter line had been retrieved, the crew on deck pulled the boat forward below the deck crane (figure 3). The 3rd engineer had climbed into the boat ready for fastening the deck crane hook to the boat. After the hook had been fastened, he swam back to the combination ladder and climbed up. He did not stay in the boat because the crew on deck were concerned about him adding weight to the damaged boat hull fearing it would break apart when hoisted.

At 1556, approximately twenty minutes after the boat fell down, the rescue boat was hoisted up and landed on the main deck. The chief officer immediately started examining the injured crew members to assess which one to bring to the ship's hospital first given that the hospital only had one bed.

Figure 4: Recovery of the rescue boat with injured crewmembers
Source: TORM A/S

The preliminary examination showed that all the crew members were responsive, but it was apparent that the chief engineer needed immediate treatment and was therefore lifted from the boat and brought to the ship's hospital. The cadet and the 3rd officer were afterward brought to the ship's gymnasium. Radio Medical Denmark was contacted and the crew on TORM MAREN were advised about appropriate medical treatment of the injured persons and was told that the patients had to be disembarked as soon as possible. Meanwhile on the bridge, the master and 2nd officer discussed which nearby ports or anchorages could be used for disembarking the injured crew, and it became apparent that the nearest suitable option was the anchorage at Conakry, Guinea, approximately 115 nm from TORM MAREN's present position. At 1610, the master called the company office and notified personnel from the emergency response team about the accident and discussed arrangements for disembarkation.

At approximately 1745, TORM MAREN was underway on an easterly course to Guinea awaiting an update on whether it would be possible to disembark the injured crew in the port of Conakry. While underway, Danish Joint Rescue Coordination Centre (JRCC) established contact with the ship and notified the master that a Spanish naval ship with medical personnel on board was nearby. Later in the evening at 2050, the naval ship contacted TORM MAREN and offered their assistance. A medical team was dispatched and came on board to examine the patients and provided medication for pain relief. Without advanced medical equipment they could not offer the patients further treatment, and the medics left the ship a few hours later.

The next morning, TORM MAREN arrived at Conakry anchorage and contacted the port authorities and arranged the disembarkation of the injured crewmembers. After some negotiation, the crew was allowed to be transferred to a service boat and brought to shore and the hospital.

Investigation

SCOPE OF THE INVESTIGATION

DMAIB was notified about the accident in the morning of 2 April 2020. The accident was considered serious due to the severity of the crew's injuries caused by a failure of safety critical equipment. Consequently, a full investigation was launched. Due to the Covid 19 pandemic situation it was not possible to gain access to the ship. Therefore, the ship crew was tasked with collecting evidence, and interviews were conducted via telephone and video conference calls. During the preliminary investigation, it was found that the wire lifting rope was severely corroded which caused it to part during retrieval of the rescue boat. The scope of the investigation was therefore focused on answering three questions.

- Why was the wire rope corroded?
- Why was the condition of the wire rope not acted upon by the ship's crew?
- Why was this safety critical system susceptible to a single point failure?

To answer these three questions, three topics were examined: The wire rope, the ship's maintenance practises and the reliability of the rescue boat davit.

The wire rope

DMAIB received both ends of the parted wire on 9 April 2020 and conducted a preliminary investigation and documentation of the wire before it was brought to FORCE Technology for a detailed examination of its condition.

Investigation of wire rope by DMAIB

The investigation conducted by DMAIB focused on describing the wire rope's type and origin, documenting the condition of the wire and determining how far the boat had been hoisted when the wire rope parted.

In October 2018, during the five-yearly inspection of the rescue boat system, the wire rope had been changed. The new Quality Wire Rope Certificate dated January 2018, stated that the wire rope was a 10 mm single layer, zinc coated, non-rotation wire rope. This specification was concordant with the requirements stated in the rescue boat system manual. The wire rope was manufactured in January 2018, nine months prior to installation on TORM MAREN.

DMAIB received the part of the wire rope which was attached to the rescue boat and approx. 4 m of wire rope which was left on the crane and winch. The wire rope had been broken off approx. 1,175 mm from the eye where the boat hook had been fitted (figure 5).

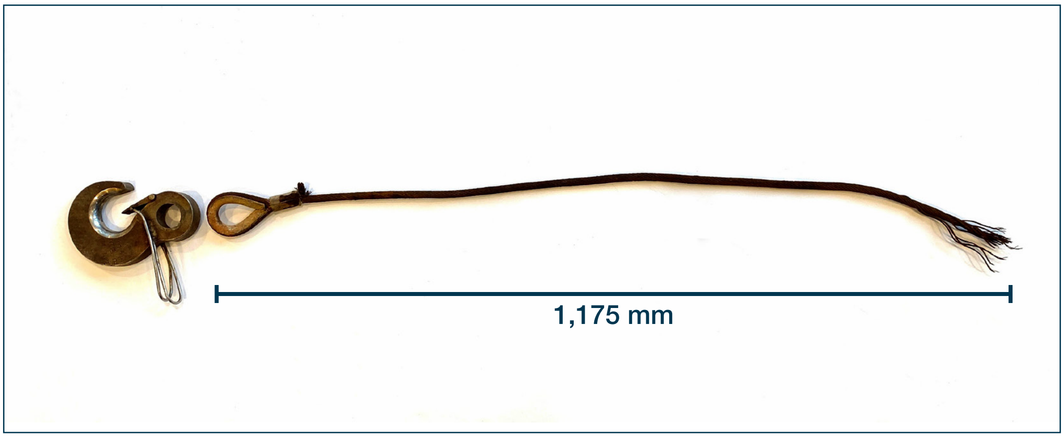

Figure 5: Parted wire rope from TORM MAREN
Source: DMAIB

Both ends of the parted wire rope were visibly corroded, and no zinc coating was visible on either ends of the parted wire rope (figure 6). No broken strands were found on the entire length of the received wire rope, indicating that the wire rope had not been subjected to general mechanical wear and tear. The majority of strands were found to be corroded and had little or no flexibility and broke if slightly bent, indicating a noticeable depth of corrosion had occurred. Other strands had some flexibility left.

Wire rope samples, cut approximately 8 m and 25 m from the wire rope eye, were used as a comparative reference to the wire rope ends where the fracture occurred (figure 7 and 8). It was established that 8 m from the wire rope eye there was moderate corrosion and traces of lubrication were found. The latter part of the wire rope, 25 m from the wire rope eye, was normally stored on the winch when the rescue boat was in its stowed position and thus not as exposed to the environment as the part of the wire rope led to the sheave via the crane yard. Thus, a visual inspection of all the wire rope samples indicated that the condition of the wire varied significantly along its length.

Figure 6: Parted wire from boat hook end
Source: DMAIB

Figure 7: Sample wire 8 m from the wire rope eye
Source: DMAIB

Figure 8: Sample wire 25 m from the wirerope eye
Source: DMAIB

Once it was established that corrosion was the determining factor in the wire rope parting, it became relevant to examine why the particular part of the wire rope that broke was most severely affected by corrosion.

DMAIB hypothesised that the wire had been particularly exposed when it rested on the crane yard sheave (figure 9), bending it and exposing the inner strands to the marine environment and allowing sea water and rain to penetrate the wire rope. From the drawing of the rescue boat system it could be estimated that the distance from the arrangement suspension to the top of the crane yard was approx. 1,700 mm. As the parted wire connected to the hook measured 1,300 mm including the boat hook it is likely that the wire rope broke in the area where it normally passed through the guide plate (figure 9).

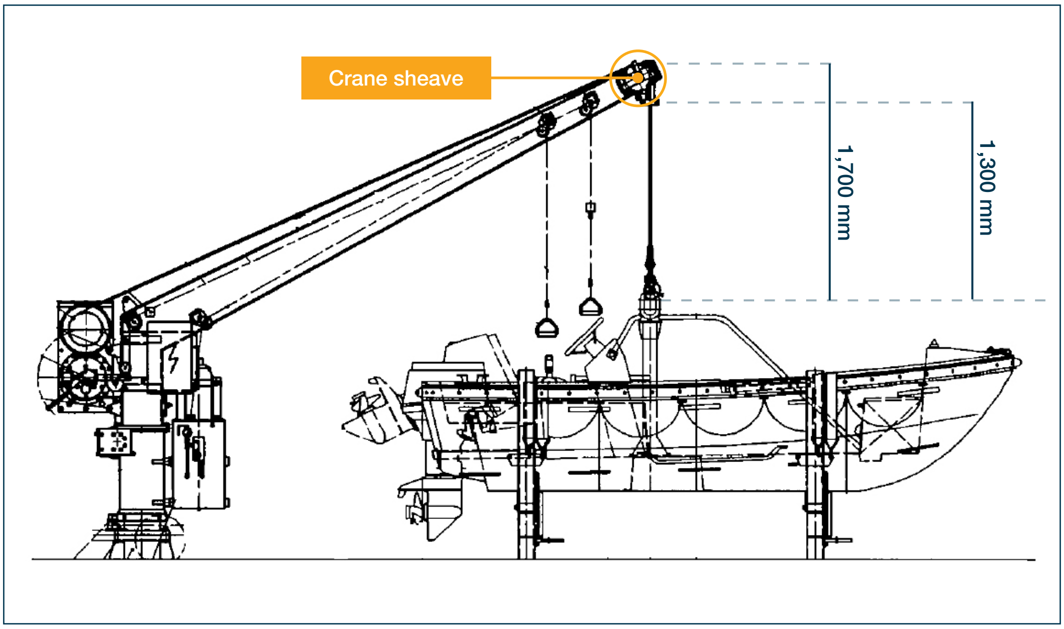

Figure 9: Technical drawing of the rescue boat system.
Source: TORM A/S / DMAIB

In this area water could accumulate in the wire guide plate, exposing the wire to water (figure 10).

The sheave was made of polyamide and turned on a stainless steel shaft and was thus not subject to corrosion. From a visual inspection of the sheave it could be seen that it had traces of residue from the corroded wire rope and had visible imprints of the wire rope in its groove. The frame on which the sheave was mounted and the guide plate were also visibly corroded.

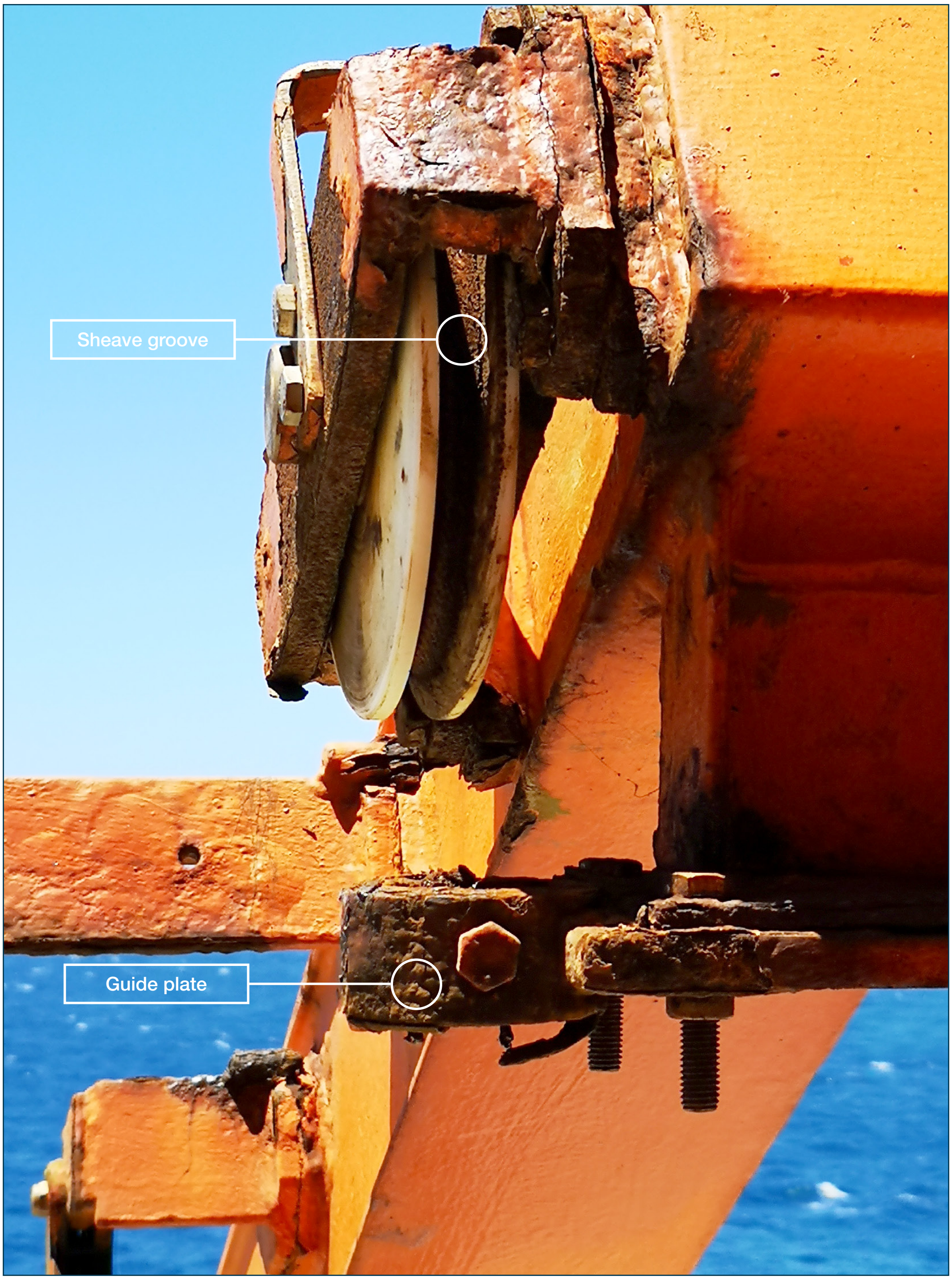

Figure 10: Crane sheave and guiding plate
Source: TORM A/S

Examination by FORCE Technology

On 15 April 2020, DMAIB brought the wire rope to FORCE Technology for examination. The scope of the examination was to establish the extent of the corrosion and the cause of the wire parting. FORCE's examination concluded the following:

> *"The results of the examinations and tests have shown that the steel wire rope has failed due to overload in tension. The cause of the overload cannot be clarified from the available information but has been demonstrated that the wire rope fracture has not been affected by prior mechanical damage or by shearing and squeezing during the incident.*
>
> *The wire rope is heavily corroded in the part open to the marine environment and not protected as e.g. from overlaying turns on the wire drum.*
>
> *By nature, chloride is hygroscopic and whenever the relative humidity exceeds ~ 40 %, corrosion is an ongoing process. The corrosion rate will increase once the protection from the grease might have been lost and the relatively thin protective zinc coating has been consumed.*
> *[…]*
> *As we do not have detailed information of the incident, we cannot conclude the full cause of failure, but it can be concluded that reduced load capacity of the wire rope due to insufficient maintenance has had a major impact on the failure".*

Additionally, FORCE Technology concluded that a visual stereomicroscopic examination of the area where the wire rope parted showed it was severely corroded, and the wire strands had a reduction of diameter in the range of 25-50%. The corrosion was general among the wire strands. There was no zinc coating left. The examination also identified that the outer and inner wire rope strands were dry and there was little penetration of lubrication to the internal strands of the wire rope. As a reference, part of the wire rope which was left on the winch was also examined. Corrosion was found to be unevenly distributed among the outer and inner wire strands which had a reduction of diameter in the range of 10-25%. Some zinc coating and residue of lubrication was found.

FINDING - WIRE ROPE FRACTURE

The wire rope was according to the wire rope certificate manufactured in January 2018 and was installed on TORM MAREN in October 2018. When the wire rope broke in April 2020, it had thus been in operation for 18 months and within that time-period a part of the wire rope had corroded to the extent that its load capacity had diminished causing it to part when exposed to load during the boat drill.

Maintenance practises

Establishing that the wire rope was severely corroded led to an investigation of the ship's maintenance practises for the purpose of identifying why the wire had not received preventive maintenance to avoid corrosion.

Planned maintenance system

The company had a planned maintenance software system used on all its ships which was designed to plan maintenance tasks in set intervals based on each asset's requirements, e.g. by either condition monitoring, meter readings or calendar dates. When the maintenance tasks described in the system had been performed, the tasks would be signed off in the system, and any comments regarding the status of the asset were recorded. The crew and company could thereby monitor the maintenance status of individual assets and components via up-to-date records. On the ship, the chief engineer was formally responsible for overall maintenance of the ship and its equipment, but in the day-to-day operations the chief officers and 2nd engineers were responsible for maintenance tasks carried out by junior officers on the deck and in the engine department.

All maintenance tasks and schedules were defined by the staff in the company's technical department in close cooperation with the on-board crew. The planned maintenance system (PMS) setup was similar across the fleet, but adapted to suit the different ship types equipped with various kinds of assets. The system allocated the maintenance to an officer who was responsible for completing the tasks according to a specified job description. Once the work was done, the task was recorded as complete, and any comment about the condition of the asset could be logged in the system.

Maintenance of rescue boat system

On TORM MAREN the rescue boat system was not listed as one asset in the PMS, but was divided into different system components, which had separate maintenance intervals, and were allocated to different officers from the engine and deck departments.

All maintenance activities related to the rescue boat were planned on the basis of requirements set out by company standards, IMO regulation (figure 11) and the manufacturer's manual.

The SOLAS III regulations 36 and 20.7 contained general requirements to the maintenance systems of life-saving appliances. MSC Circular 1206 (26 May 2006), which was effectively superseded by MSC Circular 402(96) (19 May 2016), contained requirements for thorough examination and operational testing of inter alia rescue boats. Included were requirements for the type of examinations and tests which must be carried out by certified service providers and which type of activities can be done by on-board crew.

Job No.	Component / Component Name	Location / Location name	Prio.	Description / Short comment
501.2150.01	501.2150			Weekly Inspection of Rescue Boat davit

Rescue Boat Davit & Winch

Job Origin:

SOLAS III Regulation 36
SOLAS III Regulation 20.7
MSC/1206
TORM Standard

Sources of maintenance requirements

Job Description:

a) Check that the launching arrangement is ready for immediate use, by moving from stowed position.
b) Check accumulator pressure if an accumulator is present.
c) Check the davit is set in stowed position so that the hanging hook is directly above boat's stowed position centre.
d) The rescue boat should be sitting on the stowage bracket all over not lifted clear of same by the davit.
e) Inspect the hanging off pendant connections at the boat. If any shackles used the same must be free.
f) Check suspension block can move
g) The hoisting wire on the davit should be stowed on the drum, without any turns being tucked under other stowed turns.
h) Check hydraulic level gauge visibility and level, if applicable.
i) Try out the slewing and hoisting levers if fitted to be free and the same to return to neutral position when left.
j) Verify instruction labels, poster and markings are in legible condition and that they are placed under emergency lights.

Figure 11: Reference to sources of maintenance requirements.
Source: TORM A/S

The MSC circular described how thorough annual examinations and operational tests and/or thorough five-year examinations, overhaul, overload operational tests and repairs must be carried out by certified personnel from either the manufacturer or an authorised service provider. Weekly and monthly inspections and routine maintenance, as specified in the equipment maintenance manual, must be conducted by authorised service providers or by shipboard personnel under the direction of the senior ship's officer in accordance with the maintenance manual.

The company standard was based on the manufacturers' manuals and input based on experience with similar systems. All the maintenance activities were periodical (weekly, monthly, three-monthly, annual and five-yearly) and were allocated to different on-board officers, except the annual and five-yearly which were made by service providers.

The 2nd engineer and the chief officer were the senior officers responsible for maintenance of the rescue boat system. They performed some maintenance activities themselves and delegated other tasks to the 3rd officer, 4th engineer and the electrician. Below is an overview of which officers were involved in the maintenance of the rescue boat system (figure 12). In total 13 different periodic maintenance activities related to the rescue boat system were assigned to the officers. These activities, combined with periodic drills where the boat was launched and tested, comprised the maintenance regime of the entire system.

DMAIB reviewed and mapped the rescue boat maintenance and test/drill activities from September 2018 until the latest activity performed on 29 March 2020, four days before the accident. The records showed that various crew members had inspected, performed maintenance activities or operated the rescue boat system on 45 separate occasions. A certified service provider had completed a five-yearly examination in October 2018, were the wire rope had been renewed, and a thorough annual examination in July 2019, including an examination of the wire rope which was found in good order.

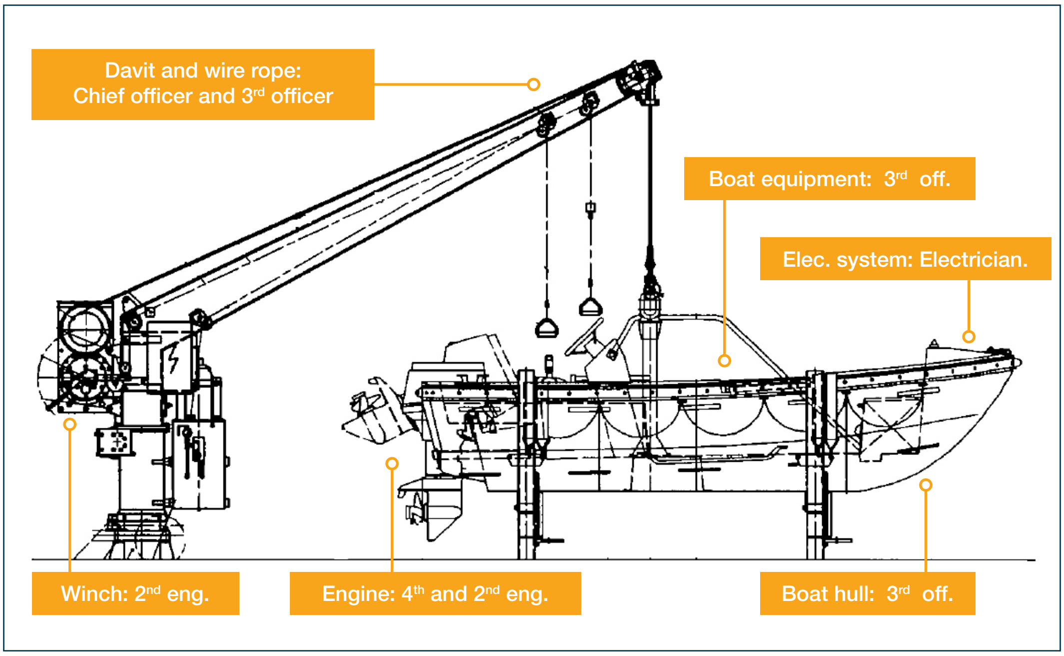

Figure 12: Persons involved in maintenance
Source: TORM A/S / DMAIB

The officers had recorded all the completed weekly, monthly and three-monthly maintenance activities. In the records there was no data that suggested that any crewmembers involved in the maintenance in the period from September 2018 until the accident had observed corrosion on the wire.

When tracing which maintenance activities included the wire rope, it was found that only the monthly check of the rescue boat davit and winch included an inspection of the wire rope (figure 13). The activities were allocated to the 3rd officer and included inspection of the rollers, sheaves and greasing of wire, if found necessary. Additionally, the wire rope was to be checked for damage and deformations. The latest monthly check had been signed off on 27 March 2020, five days before the accident.

Monthly Inspection

a) The hanging off procedure, should be considered for monthly maintenance, if possible.
b) Check insulation of starter panel for Rescue boat winch.
c) Start / EMG Stop / Stop of rescue boat winch motor to be done after running same for some time.
d) Move and test hand brake, if applicable
e) Wire to be moved manually to inspect all rollers and sheaves are moving when the wire is moving over the same, grease wire if necessary.
f) Check wire for damages and deformations
g) Inspect all greasing points and grease as necessary. Special care to be given to the turn table bearings of the Rescue boat davit, make sure grease nipples are clean before applying new grease.
h) Inspect brake lining for wear and tear follow makers instruction, change if necessary
i) Check and inspect shafts, sheaves, sheave pins, suspension blocks, cradle stopper pin and other rotating parts.
j) Check hinge pins
k) Fasten turnbuckles, if applicable
l) Check that all limit switches are working including hoisting by physically moving the davit.
m) Check oil level and condition
n) Electric inspection of limit switches, push buttons and wiring of starter panel and other electric connections.

Figure 13: Monthly check of rescue boat davit and winch
Source: TORM MAREN

Maintenance of the wire rope

The monthly inspection of the wire rope was described in two separate task descriptions (line e and f, figure 13). Both descriptions instructed the 3rd officer to make an assessment of the wire rope's condition: '... grease if necessary' and 'Check wire for damage and deformations'. The wording of the task description implied that the 3rd officer was to make a subjective assessment of the wire rope's condition. Arguably, this subjectivity was based on training, experience and the direction of the senior ship's officer in accordance with the PMS and the manufacturer's manual.

During the investigation all job origin sources (SOLAS, MSC Circular and TORM Standard) listed in the rescue boat davit maintenance activity were reviewed. It was found that the regulatory sources cited in the PMS pointed to the importance of using the manufacturer's manual when inspecting and maintaining the rescue boat system.

> *"Any inspection, maintenance, thorough examination, operational testing, overhaul and repair shall be carried out according to the maintenance manuals and associated technical documentation developed by the manufacturer.[1]"*

Therefore, the manufacturer's user and maintenance manual was examined to identify instructions on how to assess the condition of the wire rope.

The manufacturer's manual was found to be a compilation of documents from various subcontractors addressing the functionality and maintenance of individual system components. The manual prescribed in detail how to use, inspect, maintain and repair some system components, e.g. boat, engine and winch, whereas other components were only briefly mentioned, e.g. davit, sheaves, hook, wires, etc. It stated that the components were to be inspected but did not elaborate how to perform such an inspection and which criteria to use. Noticeably, the manual stated that the maintenance of the boat and crane was to be done by the ship's crew with an estimation of the intervals which depended on the frequency of operation.

The description of the three-monthly service recommended the wire rope be greased on a regular basis. This was the only place in the manual where an inspection of the wire rope was mentioned, apart from instructions on installing and changing the wire rope. The PMS and the manufacturer's manual did neither elaborate which criteria to apply when performing the inspection nor refer to recognised industry standards which provide such guidance[2]. Hence the officers tasked with the maintenance had to rely on their own expertise in making such judgements.

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1 Resolution MSC.402(96) (adopted on 19 may 2016) Requirements for maintenance, thorough examination, operational testing, overhaul and repair of lifeboats and rescue boats, launching appliances and release gear., 6.1.1.

2 ISO 4309:201019. ISO 4309:2010 (The international standard for care and maintenance, inspection and discard of steel wire ropes used for cranes and hoists.)

Competence in wire rope inspection and assessment

The company's informal policy was that senior officers were to educate and guide the junior officers on how to inspect the various components of the rescue boat davit. However, in absence of any objective guidance on how to make such an inspection and assessment of the wire rope, the senior officer would be prone to pass on his or her own subjective opinion which might not be consistent with recognised industry standards. During the investigation, DMAIB interviewed numerous officers on board TORM MAREN about maintenance of wire ropes in general and specifically the wire rope on the rescue boat davit.
During the conversations, the officers did not refer to any formal training or written guidance on how to evaluate the condition of the wire rope, or requirements for lubrication. Moreover, it was evident that the officers could not expound which criteria was used during the inspection of wire ropes. Thus, it was questionable how the officers obtained the necessary expertise in assessment of the condition of wire ropes. The 3rd officer and chief officer tasked with performing the monthly inspection of the rescue boat davit, which included the wire rope, did not have the necessary prerequisites to assess the condition of the wire rope.

Additionally, the company's informal policy was found to entail that knowledge about inspection of equipment was transferred between on-signing and off-signing junior officers during handover. However, during handover, the on-signing officer is likely to assume that the wire rope is in working order unless it is specifically addressed and discussed. The condition of the wire rope at the handover thereby formed a basis for its working condition and future inspections was measured against that observed condition. Hence, this might cause a drift in the perception of the wire rope's condition. As the wire slowly corroded over time, the officers would be prone to overlook the gradual change in the wire's condition, and therefore might not notice the degrading condition of the wire rope and did not recognise that the wire likely already was corroded when the officer signed on the ship two months prior to the accident. Additionally, the officers' trust in the wire rope's initial condition was found to be reinforced by the wire rope being subjected to annual thorough examination by a certified service provider and replaced on a five-yearly basis. It was thus not recognised that the wire could deteriorate within the time span from the last thorough examination in July 2019.

FINDING - MAINTENANCE PRACTISES

It was found that the inspection and maintenance of the wire rope was included in the PMS monthly check of the rescue boat davit. The PMS relied on the officers in charge of the inspection making subjective judgements about the wire rope's condition based on guidance offered by the manufacturer's manual. However, the manual did not contain such guidance.

Reliability of the rescure boat davit

The rescue boat davit was part of a safety critical system designed for man overboard situations. It basically acted as a lift hoisting and lowering the boat crew from a height of approximately 15-20 metres depending on the ship's draught. Understanding how such a safety critical system became susceptible to a single point failure required an investigation of how the rescue boat davit achieved reliability.

The davit was part of a larger system consisting of mainly three parts: 1) a boat for picking up people from the sea, 2) a cradle for storing the boat and 3) the davit for launching and hoisting the boat. On figure 13 the rescue boat system is shown.

The davit had a hydraulic accumulator for slewing which could be operated from the deck or from within the boat by pulling a wire. An electrically driven winch was used for hoisting or lowering the boat. The boat could be lowered using the motor power unit, by turning the cranking gear or by releasing the brake gear which essentially lowered the boat by means of gravity at a speed controlled by a safety gear. Hoisting the boat was done by using the winch's motor power unit or by using the crank. As barriers for incorrect operation of the davit, the winch had an integrated limit switch which stopped the boat at the highest hook position and a switch which locked the electric motor, if the crank was mounted.

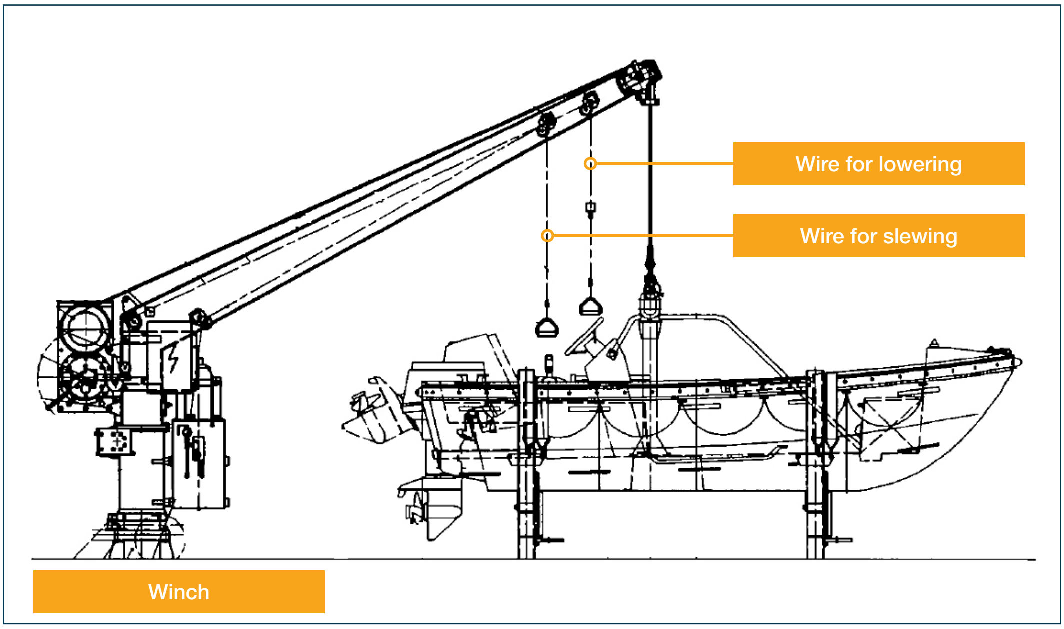

Figure 14: Rescue boat system
Source: TORM A/S / DMAIB

In this way the rescue boat could be launched and retrieved by various means of operation. These mechanical redundancies were aimed at keeping the rescue boat system operational, if one of the components malfunctioned, or if the ship lost power.

However, none of these mechanical features were aimed at preventing a single component failure to cause harm to the boat's occupants during the davit's man-riding operation. If the brake, hook, wire rope or the boat's hoisting fitting failed, the boat would be released and fall into the sea. In absence of mechanical redundancies, the reliability of the davit's man-riding capability depended entirely on preventive maintenance and regular inspection by competent personnel.

FINDING - RESCUE BOAT SYSTEM

Reliability of the rescue boat system was achieved by technical redundancy enabling the rescue boat to be launched if e.g. the ship had a power outage. However, the reliability of the davit's man-riding capability relied entirely on inspection and preventive maintenance by competent personnel.

Analysis

Analysis of the accident

During the preliminary investigation it was found that the wire lifting rope was severely corroded which caused it to part during retrieval of the rescue boat. The corroded wire rope was, however, part of a larger system comprising mechanical components, PMS, regulation, safety management system and training regimes. The parting of the wire rope was thus not the cause of the accident in itself, but an accident event which required an investigation of the circumstances leading to the deterioration of the wire rope. This investigation would enable a broader understanding of why the man-riding capability of rescue boat system failed resulting in the boat falling into the sea.

The reliability of the man-riding capability of the rescue boat system was susceptible to single point failure and relied therefore entirely on an effective PMS. DMAIB's analysis hence focused the investigation on why the company PMS was not able to prevent the wire rope from deteriorating.

The planned maintenance system

In absence of any mechanical redundancy, the safety of the davit's man-riding functionality depended on the effectiveness of the PMS task descriptions and the quality of the manufacturer's manual. However, these documents did not offer detailed guidance on how to assess the condition of the wire rope, but referred to the officers making judgements about the wire rope's condition which entailed some form of competence.

This competence as a safety critical aspect of the davit's reliability was addressed in the regulatory requirements regarding the mandatory use of authorised service providers (Res. MSC. 402(96)). However, the regulation did not state that the routine maintenance by the ship's officers required some form of competence. The regulation stated that the routine maintenance was to be performed under the direction of a senior officer in accordance with the maintenance manual, which is not a competence requirement per se, but a reference to a rank which does not necessarily entail competence in inspection and maintenance of e.g. davits. In lieu of the officers' competence, the manufacturer's manual was meant to be sufficiently elaborate to direct the officers, but with regards to the wire rope it did not offer that direction. The inspection of the wire rope therefore relied on the officers making subjective judgements on the wire rope's condition.

Judgements on the wire rope's reliability

Normally, the wire rope was mounted on the davit and connected to the boat. It was therefore readily visible for the officers involved in the operation and maintenance of the rescue boat system. The wire rope's corrosion had progressed over a period of time since it underwent a thorough examination by a service provider in July 2019, approximately eight months prior to the accident. Within that time span the condition of the wire was not acknowledged as a potential danger by the officers responsible for the maintenance of the wire rope or by the other officers involved in the maintenance and operation of the rescue boat system.

During the investigation, it was not determined with certainty why the officers did not respond to the wire rope's condition. However, the investigation of the maintenance practices provided indications of why the wire rope's condition did not translate to a recognition of danger.

In the company's PMS the rescue boat system was divided into several different system components allocated to different officers. This meant that the maintenance activities were compartmentalised, so the officers did not attend to other parts of the system they were not responsible for, unless an obvious anomaly was observed. Given that parts of the davit and the wire rope had gradually corroded, and had been so for a period of time, the officers responsible for the different parts of the rescue boat system did not view corrosion as an anomaly.

What constituted serious corrosion for the officers in charge of the wire rope's maintenance depended on an individual judgement, and in absence of particular expertise in assessing the condition of a wire rope, the initial condition of the wire became the basis for which the wire rope was inspected. When the wire deteriorated over time, as different officers signed on the ship, the initial condition changed to the extent that the wire rope's load bearing capacity was diminished. Additionally, large areas of the davit's structure showed signs of corrosion penetrating the paint, which did not impair its function, but normalised the presence of corrosion.

Among the officers a trust was found in the thorough five-yearly and annual examinations which comprised the entire rescue boat system. Arguably, it was not envisaged that the wire rope could deteriorate in between those examinations. The reliability of the wire rope therefore depended on the annual and five-yearly examinations made by certified service providers.

Conclusion

The conclusion of the investigation

The rescue boat davit's wire rope parted, because it was corroded to the extent that its load bearing capacity was exceeded when the rescue boat was hoisted. However, the parting of the wire rope was an accident event which could not in itself explain why the rescue boat system failed. Even though the company's PMS instructed the officers to inspect and maintain the wire rope, they did not act upon the deteriorating condition of the wire rope. Neither did any of the other officers who continuously inspected, maintained and operated the rescue boat system even when the wire rope was readily visible.

The reason why the condition of the wire rope was not recognised as being detrimental to the functioning of the rescue boat system was a combination of three factors: Firstly, the manufacturer's manual and PMS which did not specify how to assess the condition of the wire rope. Secondly, an absence of training in assessing the wire rope's condition. Thirdly, the PMS activities were compartmentalised which in practise meant that only one person was assessing each component. Additionally, all the factors were compounded by the thorough examination performed by service providers which made the officers trust not only the load bearing capability of the wire rope, but the man-riding capability of the system as a whole.

Preventive measures

Following the accident TORM A/S informed DMAIB that preventive measures had been initiated in order to prevent similar, future accidents.

This information is stated below as a quotation.

- *”Identified minimum required certification for all wire ropes used for lifting appliances. Dialogues was taken with wire manufacturers to enhance guidance for inspection, assessment and discarding of life saving appliance wire ropes.*
- *Learning engagement tool rolled out fleetwide to enhance ship staff knowledge on upkeep on wire ropes. Tool has been developed in line with company’s Safety Leadership Philosophy, where we aim at enhancing soft skills of our seafarers*
- *Renewal frequency has been reduced to one year and frequency interval will be reviewed in future.*
- *Reporting of PMS job routines have been enhanced to bring out leading indicators and create more barriers i.e. photograph template.*
- *Reporting of Service providers that conduct annual examination have been aligned with format used in PMS routine to pick up leading indicators and create further barriers.*
- *SMS procedures enhanced by including awareness of single point failure concept and importance of its checks before engaging personnel on to these lifting equipment*
- *Working together with flag state to highlight absence of mechanical redundancies in the systems such as brake, hook, wire rope at industry level*
- *Few additional measures introduced:*
    - *Sharing fleet wide safety flash and incident for learning purpose*
    - *Detailed incident investigation report*
    - *Feedback from entire fleet for the condition of falls and hooks*
    - *Paused all lowering of boats immediately after the incident and resumed only after introducing reviewed procedures and detailed checks*
    - *Identified standard lubrication products for full fleet*
    - *Enhanced focus on Life saving appliances during internal and external audits to increase awareness and confirm on board assessment.*
    - *Sharing of learnings with Oil Majors, so the information sharing can be done for a wider range of stakeholders*
    - *Immediate incident info-sharing with peers to help them assess taking pro-active measures*
    - *Shared the information of the incident with HILO. HILO uses the shared data points to provide predictive risk model for enhancing safety onboard. This forum shares information across the shipping companies.”*

Appendix

SHIP PARTICULARS

Name of vessel:	TORM MAREN
Type of vessel:	Crude/Oil Products Tanker
Nationality/flag:	Denmark
Port of registry:	Copenhagen
Call sign:	OULI2
IMO no.:	9358400
DOC company:	TORM A/S
IMO company no. (DOC):	0310062
Classification society:	Lloyd's Register
Year built:	2008
Shipyard/yard number:	Dalian Shipbuilding Industry Co Ltd/ No.: PC11
Overall length:	244.6 m
Breadth overall:	42.030 m
Draught max.:	15.52 m
Gross tonnage:	61,724
Engine rating:	15,260 kW
Service speed:	15.3 kts
Hull material:	Steel
Hull design:	Double hull

VOYAGE DATA

Port of departure:	Lomé, Togo
Port of call:	Gibraltar, Spain
Type of voyage:	International
Cargo information:	In ballast
Manning:	18
Pilot on board:	No
Number of passengers:	None

WEATHER DATA

Wind – speed, direction:	3 m/s - WNW
Wave height:	0.3 m
Current- speed, direction:	0.5 knots - SE
Visibility:	Good
Weather conditions:	Clear
Light/dark:	Light

MARINE CASUALTY INFORMATION

Type of marine casualty:	Loss of rescue boat
IMO classification:	Serious
Date, time:	1 April 2020, 1433 UTC
Location:	Approx. 115 nm off the coat of Guinea
Position:	09°21,6 N - 016°16,8 W
Ship's operation:	Adrift
Human factor data:	Yes
Consequences:	Three persons injured. Wire broke. Rescue boat damaged.

SHORE AUTHORITY INVOLVEMENT AND EMERGENCY RESPONSE

Involved parties:	Radio Medical, Denmark, Spanish war ship
Resources used:	Medical advice, medical personnel
Results achieved:	Stabilisation of patients, medical treatment

RELEVANT PERSONS

Master:	42 years. Had been with the company for 24 years and served on TORM MAREN since May 2019. The master signed on the ship two months prior to the accident.
Chief engineer:	43 years. Had been with the company for 17 years and served on TORM MAREN since July 2016. The chief engineer signed on the ship two months prior to the accident.
2nd engineer:	35 years. Had been with the company for 13 years and served on TORM MAREN since April 2014. The 2nd engineer signed on the ship three months prior to the accident.
Chief officer:	32 years. Had been with the company for 12 years and served on TORM MAREN since September 2019. The chief officer signed on the ship three months prior to the accident.
3rd officer:	26 years. Had been with the company for 4 years and served on TORM MAREN since May 2018. The 3rd officer signed on the ship three months prior to the accident.
Cadet:	27 years. Had been with the company since December 2019 and served on TORM MAREN since January 2020. The cadet signed on the ship three months prior to the accident.