Danish Maritime Accident Investigation Board

SUMMARY REPORT

July 2014

TORM REPUBLICAN

Occupational accident on 3 December 2013

The Danish Maritime Accident Investigation Board
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Case number: 2013026421

Front page: TORM REPUBLICAN, mooring lines. 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 with a view to preventing accidents and promoting initiatives that will enhance safety at sea.

The Danish Maritime Accident Investigation Board is an impartial unit which is, organizationally and legally, independent of other parties

Purpose

The purpose of the Danish Maritime Accident Investigation Board is to investigate maritime accidents and to make recommendations for improving safety, and it forms part of a collaboration with similar investigation bodies in other countries. The Danish Maritime Accident Investigation Board investigates maritime accidents and accidents to seafarers on Danish and Greenlandic merchant and fishing ships as well as accidents on foreign merchant ships in Danish and Greenlandic waters.

The investigations of the Danish Maritime Accident Investigation Board procure information about the actual circumstances of accidents and clarify the sequence of events and reasons leading to these accidents.

The investigations are carried out separate from the criminal investigation. The criminal and/or liability aspects of accidents are not considered.

Marine accident reports and summary reports

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.

Contents

1. PREFACE

On 3 December 2013 there was a serious occupational accident on board the Danish tanker TORM REPUBLICAN in Bilbao, Spain. DMAIB's main focus areas in the investigation of the accident have been the conflicting goals that ship crews encounter and negotiate in their everyday work as well as the interrelations between regulations, procedures, crews' perception of risk and the reality they meet. This safety report is a summary of these findings.

2. FACTUAL INFORMATION

2.1 Photo of the ship

Figure 1: TORM REPUBLICAN
Photo: Ria Maat/Shipspotting.com

2.2 Ship particulars

Name of vessel:	TORM REPUBLICAN
Type of vessel:	Chemical/product tanker
Nationality/flag:	Danish
Port of registry:	Copenhagen
IMO number:	9290658
Call sign:	OYNE2
DOC company:	Torm A/S
IMO company no. (DOC):	0310062
Year built:	2006
Shipyard/yard number:	Hyundai Mipo Dockyard Company Ltd. Ulsan, Korea/0240
Classification society:	American Bureau of Shipping
Length overall:	183.2 m
Breadth overall:	32.47 m
Gross tonnage:	29,242
Deadweight:	46,955 t
Draught max.:	12.216 m
Engine rating:	8,580 kW
Service speed:	14.5 knots
Hull material:	Steel
Hull design:	Double hull

2.3 Voyage particulars

Port of departure:	Anchorage off Bilbao, Spain
Port of call:	Bilbao, Spain
Type of voyage:	Merchant shipping, international
Cargo information:	Discharging, Naphtha
Manning:	21
Pilot on board:	No
Number of passengers:	0

2.4 Weather data

Wind – direction and speed:	Southerly, 6 m/s
Wave height:	1.4 m
Visibility:	10 nm
Light/dark:	Dark
Current:	Unknown

2.5 Marine casualty or incident information

Type of marine casualty/incident:	Occupational accident
IMO classification:	Serious
Date, time:	3 December 2013 at 0254 LMT
Location:	Petronor Terminal Berth 1, Bilbao, Spain
Position:	43°22.20’ N – 003°05.67’ E
Ship’s operation, voyage segment:	Alongside
Place on board:	Main deck
Human factor data:	Yes
Consequences:	One seafarer injured

2.6 Shore authority involvement and emergency response

Involved parties:	Terminal, ambulance/paramedics/doctor, police
Resources used:	2 ambulances, paramedics, doctor, police
Speed of response:	12 minutes (from emergency call to arrival of ambulance)
Actions taken:	Injured person brought ashore
Results achieved:	Injured person hospitalized for treatment

2.7 Scene of the accident

Figure 2: Scene of the accident. Insert: Close-up of terminal
Source: Google Earth

3. NARRATIVE

3.1 Background

The Danish products/chemical tanker TORM REPUBLICAN was operating in world-wide tramp trade, i.e. trading on the spot market without a fixed schedule or ports of call. During the previous year, the ship had called at 33 ports in USA, South and Central America, the Far East, Europe and Africa. On 25 November 2013 the ship anchored off Bilbao, Spain, arriving from Galveston, USA with a cargo of naphtha. After six days awaiting access to the terminal, she weighed anchor on 1 December to approach the port of Bilbao. The berth was designed for tankers with a displacement of 25,000-500,000 tonnes and a L_{OA}[1] of 150-400 m. For vessels of 50,000 DWT[2] and above a minimum of eight mooring lines at each end was a requirement from the terminal.

At the time of the accident, the crew consisted of the master, seven officers, one electrician, one chief cook, one mess man, eight ratings, one cadet and one ordinary seaman trainee, 21 persons in total.

3.2 Sequence of events

TORM REPUBLICAN took pilot on 1 Decmber 2013 at 0136 hrs. and entered the port of Bilbao. The ship was moored at Petronor Terminal, Jetty No. 1 with port side alongside with a total of 12 mooring lines (figure 3).

The crew received advice on tides, mooring, swell etc. from the pilot. At the time there was a wave height of 2.4 metres and the area generally had significant tides. In addition, the location of the jetty, on the outermost end of the breakwater, meant that swell and surges from passing vessels should be expected, and as a result extra tension on the mooring lines. Because of these circumstances, the master

[1] L_{OA}: Length overall.
[2] DWT: Deadweight tonnage.

had ordered frequent, at least hourly, tending to the mooring lines.

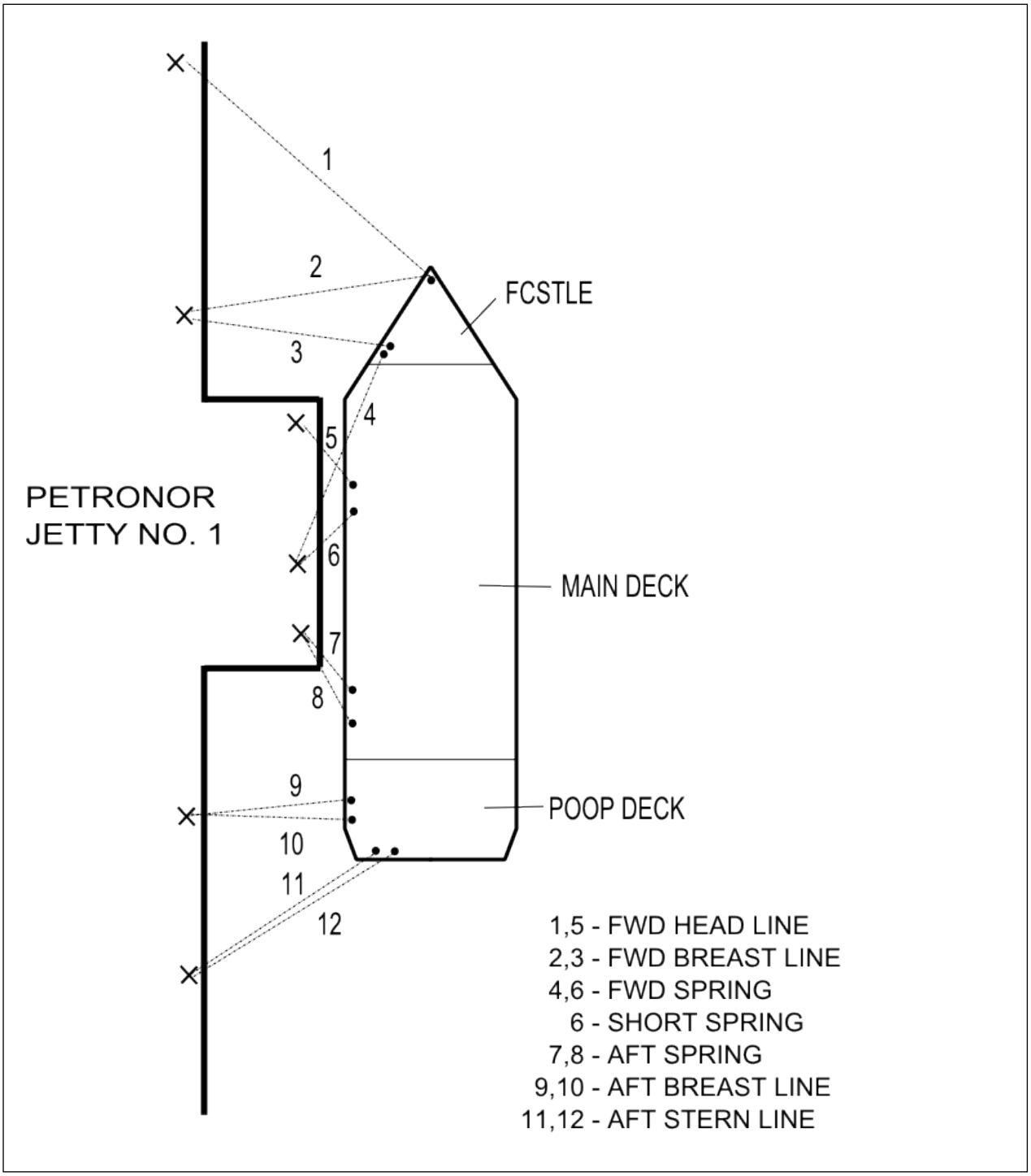

Figure 3: Sketch of mooring setup at the time of the accident. The broken spring line is no. 6
Source: DMAIB

At 0254 hrs. on 3 December 2013, the ship was discharging a cargo of naphtha from two cargo tanks in the forward part of the ship.

Two crewmembers, an able seaman and an ordinary seaman trainee, were doing a regular inspection round on deck checking moorings, gangway etc. During the round, they took the opportunity to finish an earlier task of moving a paint drum from the deck store at the manifold to the paint store under the forecastle deck (figure 4). After picking up the drum, they walked on the port side of the deck, thus having to pass the forward spring line and one of the head lines which both led from the forward starboard mooring winch to the fairleads at the side. The trainee passed first underneath both lines, pushing the bucket in front of him. When he had passed the lines, he heard some noise, looked back and found his colleague lying injured on the deck and the mooring line broken. The able seaman was severely injured, but conscious. The parted mooring rope was located some 3 metres from the railing at the side.

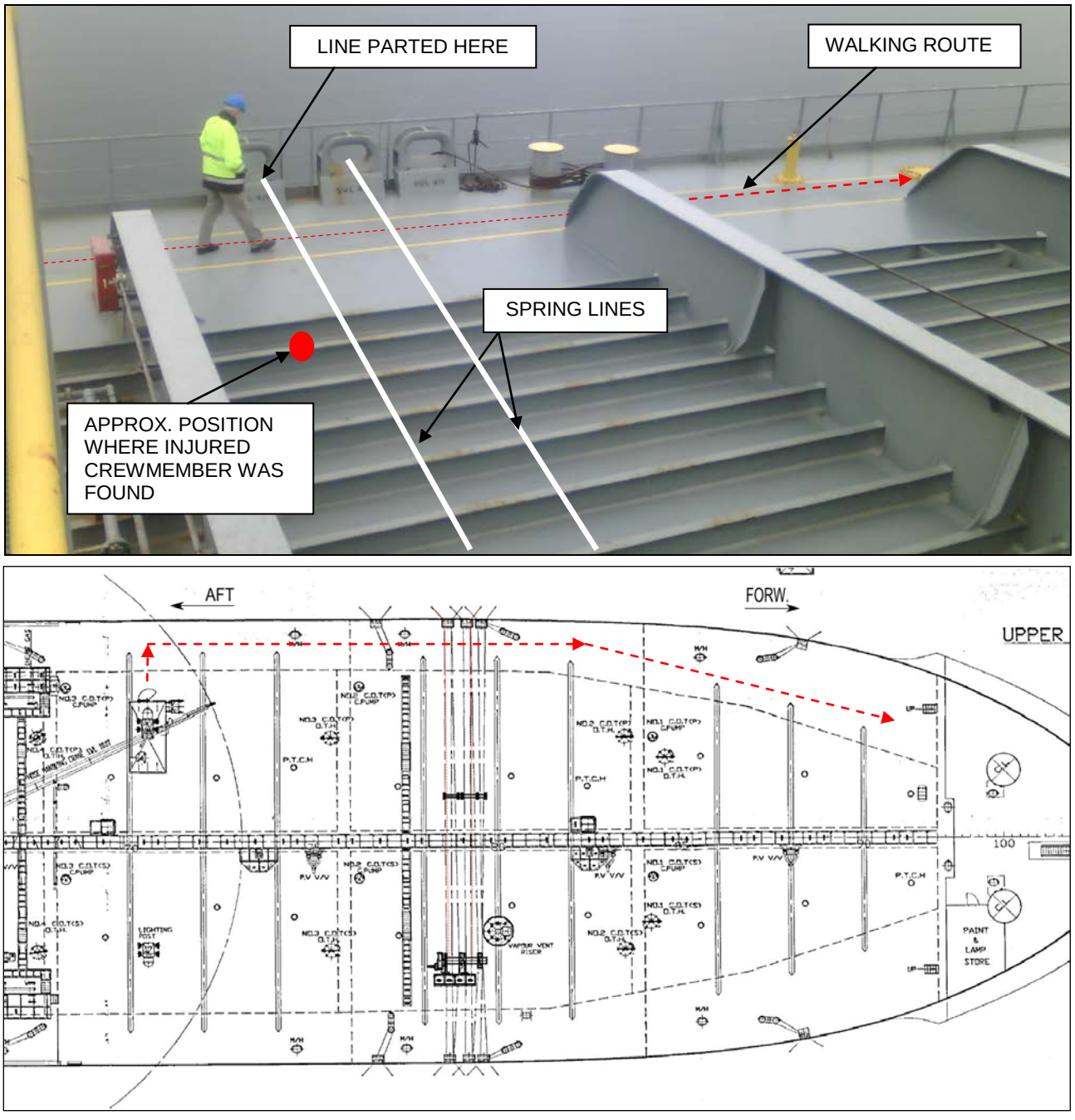

Figure 4: Bottom: Sketch of main deck seen from above. Crewmembers' walking route marked in dashed red
Top: Photo from scene of accident
Source: DMAIB

The duty officer was notified of the accident by another deck rating who came running to the cargo control room. The master was informed and the remaining crew were called for assistance. At 0300 the terminal was informed of the accident and was requested to call ambulance assistance. A few minutes later the charterer and the owner were informed. Discharge operations were stopped and the injured man was placed on a stretcher and moved from the scene of the accident.

An ambulance with paramedics arrived at 0312 and a second ambulance with a doctor arrived at 0330. At 0354 the patient was transferred to the jetty and at 0420 the ambulance left for the hospital.

The local police were on board to inspect the scene of the accident, and at 0430 the cargo discharge operation was resumed.

3.3 Mooring arrangement

3.3.1 Mooring setup

The mooring setup of TORM REPUBLICAN was typical for this type of vessel. On the raised forecastle deck, there were two combined anchor and mooring winches, one in each side. On the aft deck, there were two mooring winches of the split winch type, and on the starboard side of the cargo deck there were two split winches placed just forward of the accommodation and between the cargo manifold and the forecastle, respectively. All winches were hydraulically powered. In addition to the winches, a number of bollards, bitts and rollers were installed to accommodate various mooring scenarios. Generally the ship moored according to terminal requirements, often in a configuration called 2+2+2. This configuration, which was also used on the day of the accident, meant that two head lines, two spring lines and two breast lines at each end were used.

The spring mooring lines shown in figure 3 above (nos. 5 and 6) were led from the mooring winch placed on the starboard side of the cargo deck, forward of the manifold area. Because of the inexpedient match between the particular jetty and the ship, the forward spring lines had a very short lead and a steep angle which is not desireable as it has a negative effect on the strength and flexibility of the mooring line (figure 5).

Figure 5: Spring line similar to the parted one. Photo taken on the night of the accident
Source: TORM

The vessel was berthed at the outermost end of the breakwater with very little protection from the sea and some effect of the waves was expected, as well as occasional surges from passing vessels. During the ship's stay at Bilbao, the tide varied approximately 3.5 metres. The combination of these factors meant that the crew needed to attend to mooring

lines regularly, and thus the master had issued standing orders to this effect.
At the time of the accident, the ship was discharging from two forward cargo oil tanks. The combined effect of the rising tide and the vessel's bow rising due to the discharge caused increased tension on the spring lines.

When the ship was moored with the port side alongside, as it was in this case, the lines were led across the cargo deck to the port side fairleads (figure 6). The spring lines consisted of a 220 metre mooring wire and an 11 metre rope tail attached to it. Normally the wire part of the line would rest in the fairlead, but in cases like the present with very short moorings the rope part was in the fairlead.

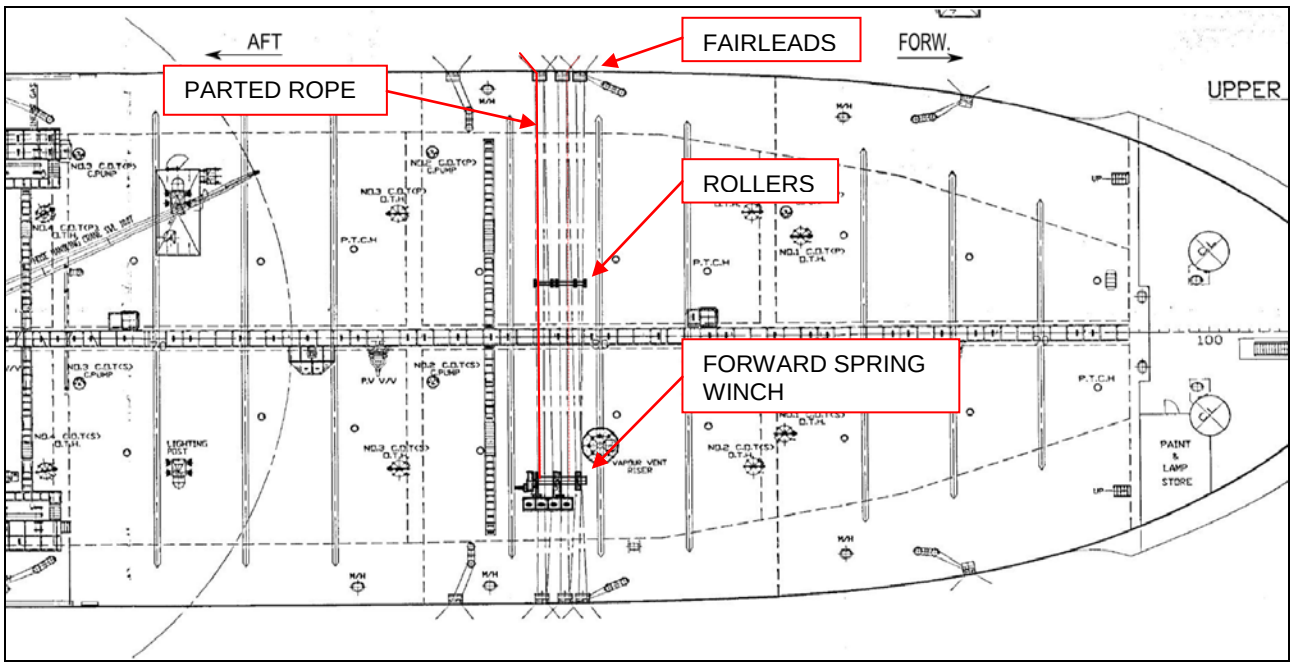

Figure 6: Sketch of forward spring mooring arrangement
Source: DMAIB

The mooring setup on TORM REPUBLICAN was such that the weakest link in case of overload should be the winch brake (set at 30.6 t) followed by the wire (nominal breaking strength 55.8 t), the rope tail (nominal breaking strength 73.5 t) and lastly the fixed structures such as the winch foundation and the fairleads. This setup is the standard and is intended to minimize the consequences in case of overload. Contrary to the intended functionality, on the day of the accident the winch brake was not released and the rope burst.

The brake holding power of the winches was checked on a regular basis. For the particular winch the latest test was carried out on 18 September 2013, confirming the setting of the brake force at 30.6 tonnes. There were no company requirements for calibrating the equipment used for the winch brake holding tests.

To avoid chafing it was normal procedure to apply grease to the fairleads. This practice resulted in the mooring wires and ropes being soiled.

3.3.2 Snap back zones

When mooring lines break, they will snap back to the point to which they are fixed, i.e. winches, bollards, rollers or bitts. Snap back zones[3] are the areas which constitute the most likely and therefore dangerous locations for a person to be in if a mooring line breaks. Snap back zones are usually painted on the deck describing an angle, indicating the area to avoid (figure 7).

[3] For detailed information on snap back zones, refer to *OCIMF Mooring Equipment Guidelines*, 3rd Edition and www.seahealth.dk.

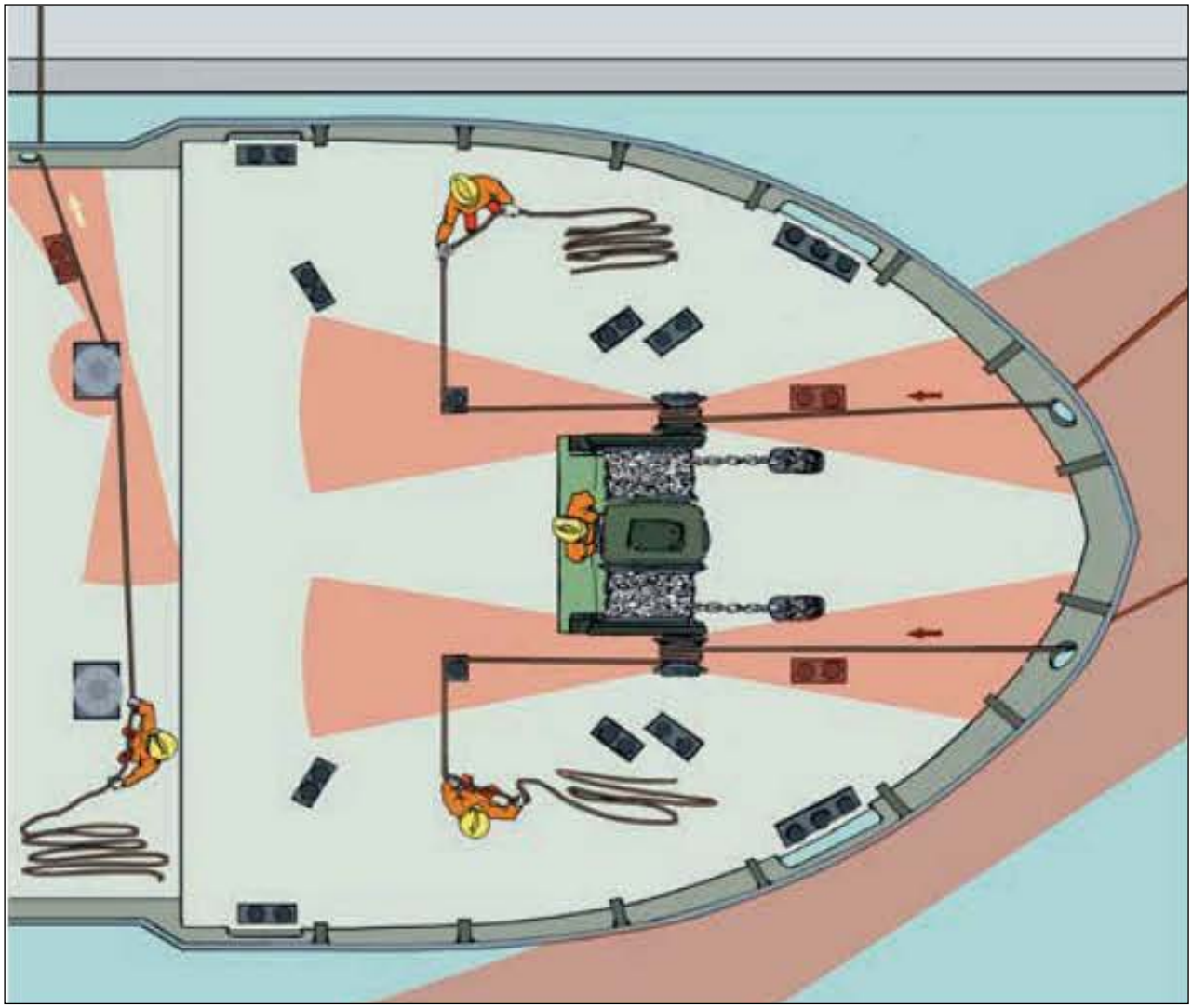

Figure 7: Example of snap back zones
Source: Seahealth.dk

The snap back zones are generally defined considering the elasticity of the lines used, the angles and leads which are commonly used on board and the predominant expected 'behaviour' of a parting mooring line. The possible area of the snap back zone of the rope when it recoils will increase in breadth the further it travels from the point of breakage. The end of the broken rope may also recoil past the point to which it is secured to a distance almost equal to the remaining length. A mooring line which is leading around a pedestal roller will whip back in a wide arc as it returns to the point to which it is secured.

TORM REPUBLICAN had snap back zones marked on the deck. In the area where the accident happened, no zones were marked on the deck. Figure 8 shows the snap back zones at the similar position in the starboard side.

Figure 8: Snap back zones at starboard side forward, TORM REPUBLICAN
Source: DMAIB

3.3.3 Procedures and risk assessments

Among the tools available to the ship's crew was a shipboard manual which contained a section on safe mooring operations. The shipboard manual is a generic document and is not made specifically for the individual vessel. The main areas that the manual describes are types of mooring operations, familiarization, lists of factors to consider, the use of shackles, mooring management and general safety reminders. Examples of the latter include: *"Always stand well clear of a mooring line under load.", "... synthetic fibre ropes give little or no warning when it is about to break ..."*

A risk assessment was also available on board, containing a selection of identified risks and their countermeasures which were to be considered in connection with mooring operations. Among the items dealt with in the risk assessments were: Fatigue, lack of competency, running of wires, rotating machinery, manual handling and poor communication.

As per company procedures, mooring lines were used for a maximum of 18 months after which they were replaced. The parted mooring rope tail had been brought into service on 24 August 2012 and thus was due for replacement in approximately 3 months.

3.3.4 The parted mooring rope

The parted rope tail was an 8-strand nylon rope, 64 mm in diameter and 11 metres long, with covered (chafe protected) eye splices at both ends. When new, the rope had a minimum breaking strength of 162,000 lbs (approx. 73.5 tonnes).

This type of rope has an indicator strand woven into it over the full length of the rope. The indicator strand will break when the rope is subjected to elongation in excess of 30%.

Examination of the parted rope tail revealed the following:

- The rope tail burst as a result of overload. Most cords showed signs of breaking due to overload (figure 9).
- The breaking strength of the rope may have been reduced by as much as

30% due to wear (chafing). Many strands and cords showed general signs of wear and chafing, especially around the location of the break (figure 10).

- While the use of grease on ropes in it-self probably did not reduce the strength, the grease did make it difficult to establish the condition of the mooring ropes.

- The indicator string was broken and fragmented along the full length of the rope, indicating that at some point in time the rope had been subjected to elongation in excess of 30%. In its original, undamaged condition this type of rope can withstand elongation of approximately 50% before breaking. It was not possible to establish whether the elongation happened just prior to the rope parting or on an earlier occasion.

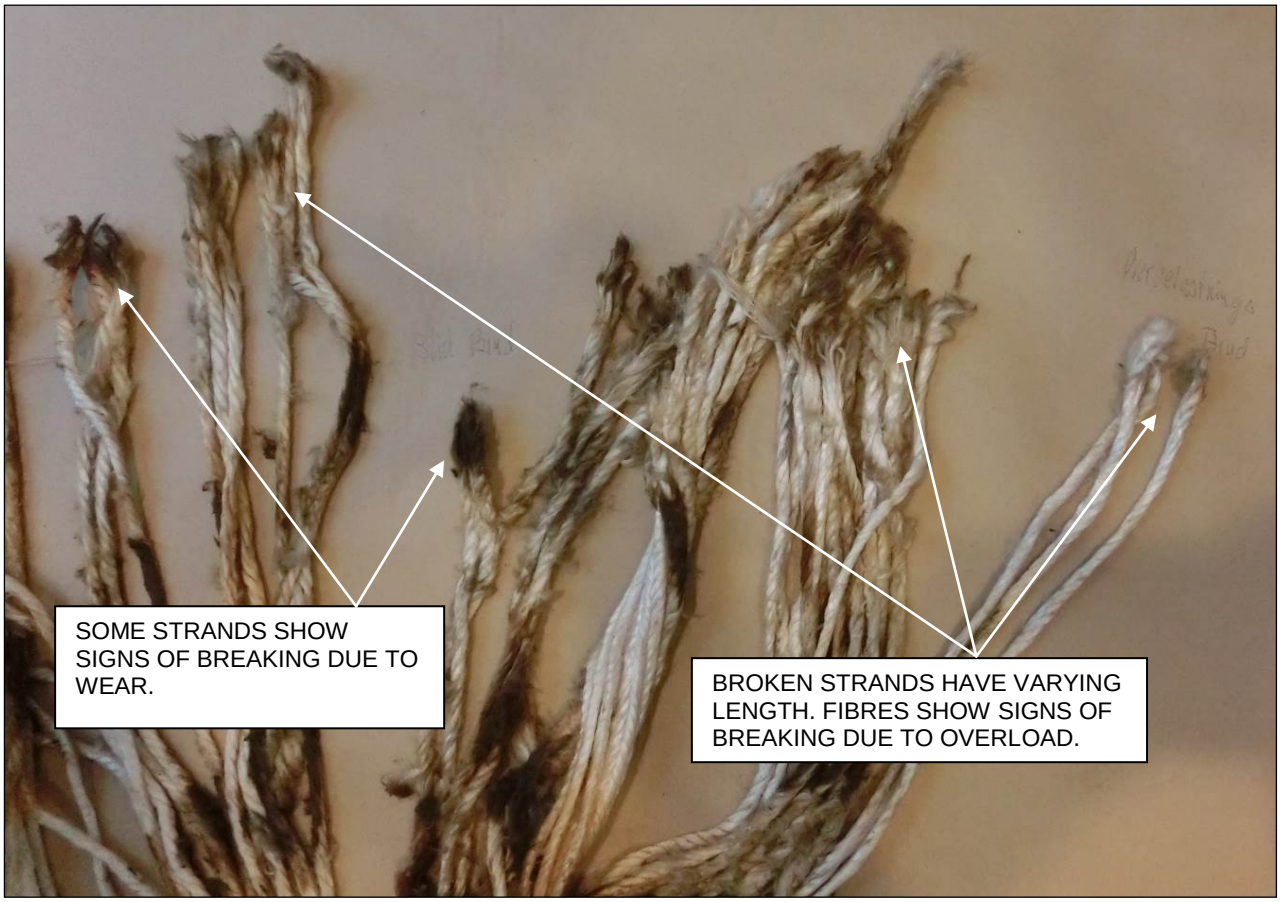

Figure 9: Details of the parted rope end
Source: DMAIB

Figure10: Details of parted rope. Both pictures show discolouration from grease
Source: DMAIB

4. ANALYSIS

The accident occurred when a crewmember passed beneath a mooring line just as it broke. In analysing the accident, focus will be on two main items; the parting of the rope and the general mooring operation and the procedures leading up to the occurrence.

4.1 Parting of the mooring line

It was established that the rope end parted as a result of overload and that the winch brake did not release before the rope broke. The possible explanations for this are:

- The brake setting may have deviated from the expected. The brake holding power of the winch was tested and adjusted using an uncalibrated instrument.

- The breaking strength of the rope was reduced due to abrasions from chafing and a previous elongation which had caused permanent deformation.

- A combination of both.

- Also contributing to the parting of the rope was the tide, the cargo discharge from the forward tanks and the inexpedient short lead and steep angle of the spring line.

4.2 Mooring arrangement and operations

When analyzing the accidental events on TORM REPUBLICAN, it can in hindsight be argued that the crewmembers should have recognized the danger of passing underneath a mooring line under tension. The question of why they chose to pass the mooring line must be understood with the crewmembers' viewpoint in mind.

On the day of the accident, they had the task of doing an hourly round to inspect and tend to the moorings, and the job of moving a paint drum forward. In an optimization process these two tasks were not seperated and the

tasks were completed in what was thought of as a meaningful and low risk manner. They could have chosen an alternative route from the deck store to the paint store which would not bring them close to the line, but then they needed to go back to tend to the mooring lines. As the deck hands were handling mooring lines on a daily basis, it was not considered dangerous to be near them. Further, the mooring rope spanned from one side of the ship to the other offering little room for the crew to pass them without being in a snap back zone depending on where the rope would break.

The shipboard manual and risk assessments did list a number of factors and risks to consider in connection with mooring operations, but the task of tending and checking moorings was not dealt with in detail. For instance, neither the manual nor the risk assessments suggest how to tend to moorings without positioning oneself in a dangerous situation or area. A number of normative terms are used, such as *"always stand well clear of a mooring wire under load"*, *"proper and correct maintenance"* and *"good, seamanlike line tending".* The practical use of such terms is probably limited in an everyday working situation.

Common to many such procedures is that, although taken individually they offer sound advice, procedures cannot cover every possible situation and are often contradictory, for example, the combination of crewmembers being told to a) Always stay clear of lines under tension and b) Tend to all mooring lines at least once an hour.

The other identified hazards listed in the risk assessments such as fatigue, lack of competence, poor communication etc. are real hazards to be dealt with. However, the control measures to be implemented do not necessarily address the underlying problems. For example, in the risk assessment the control measure to counter fatigue is: *"Officers to ensure that they are as well rested as possible prior to port operations. Chief Officer to ensure that crew members are likewise rested."*[4] Issues that are not addressed in detail are *how* the crew should ensure that they are well rested and what they should do if they do not feel up for the task?

Snap back zones might offer some valuable assistance in establishing safe and unsafe areas on deck. However, unless a vessel has a very fixed system of mooring, for instance ships repeatedly calling at the same ports all the time, the establishment and marking of possible snap back zones can easily lead to more confusion than clarification. Another problem with marking unsafe areas is the risk that all other areas are then considered safe, which is not necessarily the case. When mooring lines break, it is not possible to predict exactly which way they will travel and thus no area near moorings can be considered completely safe.

Another factor that may contribute to this type of accident is the rather strict mooring requirements and guidelines set by terminals. This could create a tendency to weigh compliance higher than safety issues when selecting the mooring setup. In this instance the requirement from the terminal was to deploy six mooring lines at each end. This may have resulted in the decision to use the two forward spring lines despite the fact that it was known they would have short leads and steep angles. While, on the one hand, the ports' requirements and guidelines can be both reasonable and helpful, on the other hand, they could also restrict the master and crew in their decision making. One example is the prohibition of using constant tension winches which is widespread in oil terminals. Although not necessarily the solution to all mooring problems, constant tension winches may have been able to prevent some accidents in the past. These are general issues and not particular to this accident.

[4] Quote from Risk Assessment MEG3 Effective Mooring

5. CONCLUSIONS

The accident on TORM REPUBLICAN occurred as a result of multiple coinciding factors:The layout of terminal/jetty vs ship size and layout, a mooring line which had a reduced breaking strength, and the unfortunate coincidence that the rope parted just as the crewmembers were passing beneath while doing normal maintenence work.

Common to many mooring accidents is that they happen under normal circumstances and are not exclusively due to some extraordinary outside influence or human action or omission. Mooring operations are routine jobs which are carried out by the crew on a regular basis and are therefore not considered to expose them to an immediate hazard. Since all work contains an element of risk, it will always be carried out as a result of a negotiation of two different goals: Getting the job done, and being safe. Understanding this negotiation is essential for creating safety.

Mooring arrangements are sometimes designed in such a way that they become inherently dangerous, which will challenge the way crews operate despite the efforts made to develop safe mooring practices. Great forces are present: Winches, mooring lines and wires under tension, people physically operating very close to these forces with limited visibility, time constraints and very little room to operate. Because of the complexity of mooring arrangements and operations and due to the designs that are sometimes inherently dangerous, it is difficult for the crewmembers to predict where the safe areas are, if there are indeed any safe areas. The design of the mooring arrangements makes it very difficult for crews to operate safely as they have no other option than to be physically very close to the equipment, thus repeatedly putting themselves in danger.

6. PREVENTIVE MEASURES TAKEN

Following the accident the company carried out an internal investigation. Among the preventive measures taken are:

- A detailed ‘Safety Flash’ and safe mooring guidelines were sent to all fleet vessels.
- On-board debriefing on safety procedures and awareness carried out by Safety superintendent and Head of SQE.
- The vessel was to conduct an extraordinary safety meeting regarding the incident, with emphasis on mooring procedures and safety.
- A follow-up extraordinary internal ISM audit to be carried out on the vessel to review safety procedures and awareness.
- Ship’s mooring winch brakes to be re-tested to check if settings are correct.
- Incident findings to be shared with entire fleet.
- Safe mooring procedures in QMS to be amended to highlight risks associated with short mooring lines, unsuitably placed bollards and movement of vessel causing chafing of mooring lines.