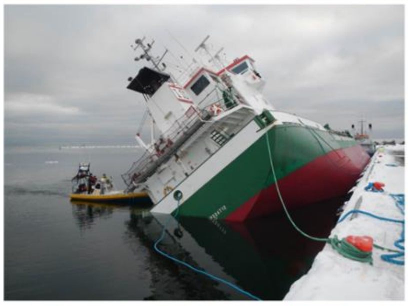
Statens haverikommission
Swedish Accident Investigation Authority



Final report RS 2014:03e

Fatal accident on board the Morraborg in the port of Holmsund, in the county of Västerbotten, Sweden 3 July 2011

File number S-95/11

4/25/2014

SHK investigates accidents and incidents from a safety perspective. Its investigations are aimed at preventing a similar event from occurring again, or limiting the effects of such an event. The investigations do not deal with issues of guilt, blame or liability for damages.

The report is also available on SHK´s web site: www.havkom.se

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This document is a translation of the original Swedish report. In case of discrepancies between this translation and the Swedish original text, the Swedish text shall prevail in the interpretation of the report.

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General observations

The Swedish Accident Investigation Authority (Statens haverikommission – SHK) is a state authority with the task of investigating accidents and incidents with the aim of improving safety. SHK accident investigations are intended to clarify, as far as possible, the sequence of events and their causes, as well as damages and other consequences. The results of an investigation shall provide the basis for decisions aiming at preventing a similar event from occurring again, or limiting the effects of such an event. The investigation shall also provide a basis for assessment of the performance of rescue services and, when appropriate, for improvements to these rescue services.

SHK accident investigations thus aim at answering three questions: *What happened? Why did it happen? How can a similar event be avoided in the future?*

SHK does not have any supervisory role and its investigations do not deal with issues of guilt, blame or liability for damages. Therefore, accidents and incidents are neither investigated nor described in the report from any such perspective. These issues are, when appropriate, dealt with by judicial authorities or e.g. by insurance companies.

The task of SHK also does not include investigating how persons affected by an accident or incident have been cared for by hospital services, once an emergency operation has been concluded. Measures in support of such individuals by the social services, for example in the form of post crisis management, also are not the subject of the investigation.

Investigations of aviation incidents are governed mainly by Regulation (EU) No 996/2010 on the investigation and prevention of accidents and incidents in civil aviation and by the Accident Investigation Act (1990:712). The investigation is carried out in accordance with Annex 13 of the Chicago Convention.

The investigation

On 3 July 2011, SHK was informed that a fatal accident had occurred onboard the Dutch general cargo vessel *Morraborg* while berthing at the port of Holmsund, Sweden.

The accident has been investigated by a SHK team including Ms. Carin Hellner as Chairperson until January 2012, Mr. Jonas Bäckstrand as Chairperson from February 2012, Mr. Per Lindemalm as Investigator in Charge until September 2011, Ms. Ylva Bexell as Investigator in Charge from September 2011, Mr. Jens Olsson as Investigator on Human and Organisational Factors from December 2011 until May 2013, Mr. Alexander Hurtig as Investigator on Human and Organisational Factors from May 2013.

The investigation team of SHK has been assisted by Mr. Alexander van der Zee and Mr. Maarten Vlaag as representatives of the Dutch Safety Board (DSB).

The work of the investigation team has been followed by Mr. Jörgen Zachau of the Swedish Transport Agency until June 2013 and by Mr. Erik Sandberg from June 2013.

SUMMARY

The cargo ship Morraborg, registrered in the Netherlands, arrived to Holmsund harbor 3 July 2011 with a cargo consisting of parts for wind turbines. In connection with the mooring of the ship a spring line was thrown from the ship's starboard side. The ship was then maneuvered by running against the spring line with the rudder hard to port in order to get the stern closer to the quay. The spring line burst and sprung back in such a way that the rope hit the chief officer. He died of his injuries.

The accident has been investigated by the Swedish Accident Investigation Authority with the assistance of the Dutch Safety Board.

During the investigation it has been established e.g. that the shipping company, Wagenborg Shipping BV, has not identified mooring work as a hazardous work. This means that no risk analysis of the procedures for mooring work has been performed. Furthermore, the investigation has established that the work area on the mooring deck was not optimized in order to carry out the task in a satisfactory manner while maintaining safety for the crew.

At the time of the accident the master, an apprentice and a pilot were on the bridge. The exchange of information between them was insufficient and there were misunderstandings about certain maneuvers.

There was no visibility between the bridge and the forecastle, which resulted in the inability for the master to ascertain that the dangerous area on the forecastle had been evacuated when maneuvering the ship.

Safety recommendations

Based on the facts and the conclusions drawn from the investigation SHK hereby recommends;

Wagenborg Shipping BV to make a more comprehensive risk analysis for mooring work at least taking into account:

- Strength and quality of mooring lines in relation to their operational use
- The potential need for tug boats to assist in mooring operations
- Scheduled inspection and maintenance of mooring lines and mooring equipment, including load test of winch manual band breaks.
- Position of winch control boxes taking into account potential snap back zones
- How to ensure the possibility to supervise the mooring operation from a safe position
- The need for operational procedures and proper communication
- How to ensure safe design of mooring stations on new built ships,

Based on the results of the analysis, establish an action plan to enhance mooring safety and take appropriate actions for existing and new built vessels. *(RS 2014:03 R1)*

Sakhalin Shipping Company (SASCO), who is the present owner of the *Morraborg*, to undertake a risk analysis on mooring taking into account what is stated in (RS 2014:03 R1) for Wagenborg shipping BV, and establish an action plan to mitigate the particular risks associated with mooring operations of this vessel. *(RS 2014:03 R2)*

Wagenborg Shipping BV to review the functionality of the bridge remote control boxes on the sister ships of *Morraborg* and take any appropriate action to ensure their good operation and their use. *(RS 2014:03 R3)*

Dutch mariners union, Dutch Shipowner association, to consider a review issued mooring instructions with regard to the extent of snap back zones. *(RS 2014:03 R4)*

Ministry of Infrastructure and the Environment of the Netherlands to raise the issue of a legal requirement to save data from (S-)VDR in ships flying the flag of the nation. *(RS 2014:03 R5)*

1. FACTUAL INFORMATION

Interviews and collection of data

In accordance with EU Directive 2009/18/EC, the Swedish Accident Investigation Authority (SHK) and the Dutch Safety Board (DSB) agreed that SHK would act as the lead investigating State in the investigation, with DSB acting as substantially interested State.

SHK and the DSB performed joint interviews with officers and crew on board M/S *Morraborg* on 6 July 2011, i.e. three days after the accident. The ship was moored alongside the same berth as on the day of the accident but with port side to the quay.

Those interviewed were the master, the boatswain and the able seaman, who both were part of the mooring crew on the forecastle, the apprentice who acted as helmsman and the chief engineer.

In addition the superintendent from the shipowner was interviewed. He had travelled to Holmsund as soon as the news of the accident reached the shipping company. The superintendent stayed on board as support for the master and crew until the unloading was completed.

The pilot was interviewed on 7 July.

Two police officers who made the technical investigation on board directly after the accident were interviewed on 6 July. The police have performed inquiries with those involved on board and written a report to which SHK has had access.

SHK and DSB have got access to photographs taken by the police and have inspected and retained those parts of the mooring rope which the police had cut off from the broken mooring line.

On 4 July a port state control inspection was performed by an inspector from the Swedish transport authority. He found five deficiencies and commented that none of these would have had any impact on the accident. The report is available at SHK.

On 5 July, i.e. two days after the accident, a post-mortem was performed on the body of the deceased chief officer at the Swedish National Board of Forensic Medicine, Department of forensic medicine, Umeå.

The ship is equipped with S-VDR. However data had not been saved in time after the accident and consequently files were overwritten and could not be used for the investigation.

Wagenborg Shipping's safety manager, who also acts as Designated Person Ashore, was interviewed by DSB regarding recruitment of officers and crew, education and training and the way the company manages safety issues and especially hazardous working moments such as mooring.

An interim report was published by SHK in July 2012, in accordance with EU Directive 2009/18/EC.

The pilot was re-interviewed in October 2012. The same day the two linesmen that assisted the vessel's berthing were also interviewed. The three interviews revealed a partly different sequence of events of the accident.

The master could not be reached for a second interview.

1.1 Ship particulars

Morraborg is a general cargo ship with single deck and two holds.

The cargo compartments are arranged to carry containers. Deck cargo may be carried on the hatches.

Flag/register	Netherlands
Identification	*Morraborg*
IMO number/ call sign	IMO 9190274/ PEBG
Vessel data	
Type of ship	General cargo ship / Container ship
New building shipyard/year	Bijlsma bv, Lemmer (the Netherlands) / 1999
Gross tonnage	6540
Length, over all	134,55 m
Beam	16,50 m
Draft, max	7,13 m
Deadweight at max draft	9149 tons
Main engine, output	Wartsila 8L38, 5280 kW
Propulsion arrangement	CPP
Lateral thruster	Bowthruster 600 kW

Rudder arrangement	Balance rudder
Service speed	14,5 knots
Ownership and operation	Wagenborg Shipping bv
Classification society	Bureau Veritas (Technical) Lloyd's Register (Company SMS)
Minimum safe manning	Five officers plus four crew

1.2 Voyage particulars

Ports of call	Rostock - Holmsund
Type of voyage	Cargo
Cargo information/ passengers	General cargo, wind power stations
Manning	Total 11
Other	Under pilotage

The ship is generally trading on medium to long voyages between ports in Europe and around the North Atlantic. During the last twelve months preceding the accident 36 port calls were made between Europe and US East Coast.

During the actual voyage calls were made in Rostock, Germany and Holmsund, Sweden. The cargo consisted of components for wind power stations. The deck cargo consisted mainly of wings for the wind turbines.

Figure 1, Morraborg berthed in Holmsund right after the accident, before discharge of the deck cargo.

1.3 Marine casualty or incident information

Type of marine casualty or incident	Fatal injury (very serious casualty)
Date and time	2011-07-03, at 10:15 h, Swedish Summer Time (SST)
Position and location of the marine casualty or incident	Port of Holmsund, Sweden N 63°41.25´, E 020°19.87’
Weather conditions	Winds from N/E, 7-9 m/s, with gusts up to 12-14 m/s
Other factors	Daylight, good visibility
Consequences	
Personal injuries	1 deceased crewmember
Environment	No consequences
Vessel	No consequences

1.4 Shore involvement and emergency response

An ambulance was ordered directly after the accident. It arrived about 20 minutes later. The pilot had run forward after the accident and immediately started cardiopulmonary resuscitation (cpr) on the spot. The crew of the ambulance continued the rescue attempt on arrival. After a while, at about 11.05 a.m. the ambulance doctor declared the chief officer dead. About 50 minutes had then elapsed since the alarm was received by the emergency call centre.

2. COURSE OF EVENTS

The *Morraborg* departed from the port of Rostock, Germany, on 1 July 2011 at 01.30 with a cargo consisting mainly of components for wind power stations. Part of the cargo was stowed on the hatches resulting in a relatively large area exposed to wind forces. The *Morraborg* arrived at the roads of Holmsund in the morning of 3 July. The pilot embarked at about 9 a.m. The weather was clear with moderate to fresh north-easterly winds with strong gusts.

On the bridge there were two persons, the master and an apprentice that acted as a helmsman, both of them were equipped with portable VHF. When the pilot arrived there was a short pilot – master information exchange. The master briefly informed the pilot about the ship's draft and confirmed that all equipment was in good working order. The pilot was not provided with any written pilot information. He had not piloted the *Morraborg* before but several others of the Wagenborg ships in the M-series. He felt acquainted with the ship type and therefore did not find it necessary to consult the pilot card posted in the wheel house before starting the piloting.

The bridge is of a traditional design with open bridge wings and a centre console for the manoeuvring. There are no bridge wing indicators fitted to show rudder position or engine applied outside, but there is a panel inside the bridge that can be turned to face the bridge wing. The panel shows rudder, pitch, engine revolutions and bow thruster. There is also a portable bridge control box that can be carried outside and used for manoeuvring the ship from either of the bridge wings.

Fig. 2, Panel with indicators that can be turned to face the bridge wing.

The dedicated wharf at the port area Hillskär is situated on the western shore of a peninsular oriented north-south and is protected from sea swell. The peninsula is, however, flat with few trees and buildings and does not provide any efficient protection from wind. The quay is about 147 meters long and consequently only slightly longer than the ship. The quay is also oriented north-south (012 deg.). The direction of the wind was consequently slightly outward from the quay and tended to prevent the ship from approaching the berth.

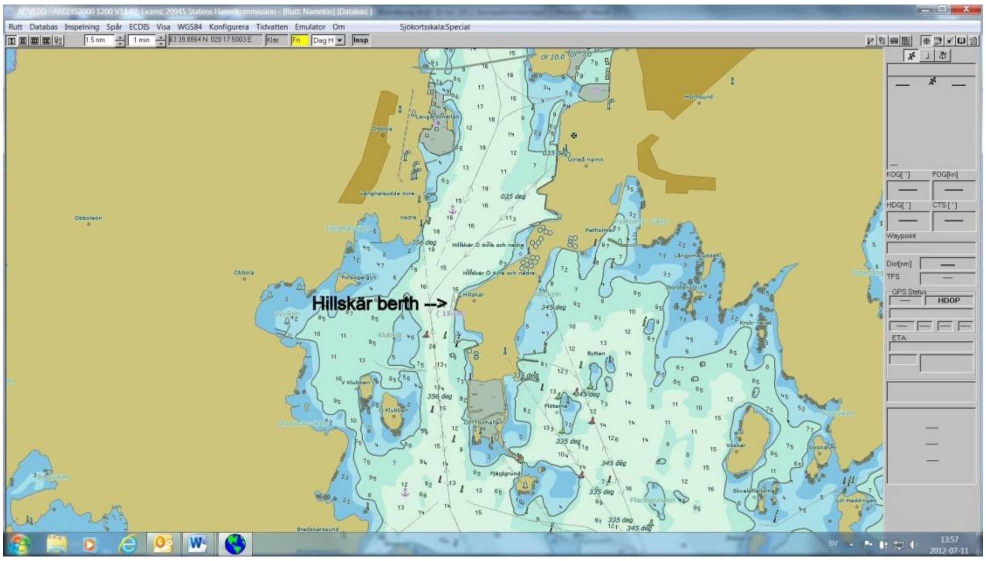


Figure 2, Hillskär berth in the port of Holmsund area. E-chart © Sjöfartsverket nr 10-01518.

At about 10 a.m. *Morraborg* had arrived into the inner port area and was approaching the berth at low speed, 2-3 knots, at an angle of 25-30 degrees to the quay. In their initial exchange of information during the approach into port, the master and the pilot had agreed to moor the ship with starboard side to the quay and to use one spring mooring line as first line ashore.

There is a tug boat available for the port. However it is not permanently crewed in summertime and in case of need the ship operator has to order assistance at least a day in advance. The pilot did not raise the question of tug boat assistance with the master as he knew that the ship had a bow thruster and as he did not consider the wind to be a problem. Neither did the master raise the question of using a tug boat.

It was the first time for the crew to moor *Morraborg* alongside this quay in Holmsund. On the forecastle were three persons, the chief officer who was in charge, the boatswain and an able seaman (AB). All of them equipped with portable VHF. One selected channel was used for communication and all involved could consequently overhear all that was said.

The chief officer was leading the team from a position by the bulwark, mid between the spring line and the head line fairleads. At this position there is a remote control unit for the wind lasses as well as a small platform enabling a person to step up for a better view over the ship's side.

Fig. 3, Morraborg after berthing in Holmsund. Another person indicates the approximate position of the chief officer at the time of the accident.

When approaching the berth the pilot asked for the portable control box which he had used on sister ships to *Morraborg* that he had piloted previously. On the box there were controls for main engine, bow thruster and rudder. The master replied that the box was not to be used but did not explain the reasons why. The pilot was not surprised by this since there had been technical problems with the bridge control box on several of the sister ships. Instead the pilot would give his orders and the master would relay them to the apprentice at the controls in the centre of the bridge. The apprentice hence operated the rudder together with the main engine and the bow thruster, together three different levers. The ship is equipped with a controllable pitch propeller and a combinatory device which coordinates propeller speed and pitch in one lever. The apprentice had received training and had operated the system a number of times. The pilot was not offered, nor was he asking for, the panel showing indicators for rudder, engine and bow thruster to be put in a position facing the bridge wing.

The pilot was standing on an elevated platform on the starboard bridge wing. He had a free view forward along the ship's side and the quay. He could not see the forecastle where the forward mooring team was working, due to the deck cargo and the high barrier that separated the foredeck from the cargo hold area. The ship carried a cargo consisting of components for wind power stations. Wings for wind turbines were carried on deck and were stowed rather high resulting in a relatively large area exposed to wind forces.

The door on the starboard side of the navigation bridge was open and the apprentice could hear the orders from the pilot. The master moved between the bridge wing and the interior of the bridge to supervise the manoeuvres and to communicate with the pilot and the apprentice, as well as with the mooring teams via portable VHF.

The pilot was alternating in the manner of which he was giving engine orders. Sometimes he gave the orders in pitch-levels instead of the more common orders "dead slow ahead", "slow ahead", etc. The closer they came to the quay the more he used orders in pitch-level. This because he could get more precise maneuvers by using a pitch-level in between e.g. "slow ahead" and "dead slow ahead".

The pilot gave the orders in English. The master also spoke English to the apprentice. At some occasions, however, the pilot noted that the master also used another language. Orders were repeated back to the pilot, but he received no verbal confirmation from the master or the apprentice that the orders were executed. Neither did the master challenge any of the orders given by the pilot.

The ship approached the berth at an angle of 25-30 degrees with the bow close to the quay. The heaving line used to pull the spring line over to the quay was thrown and reached the quay where two linesmen hauled the mooring line in and laid the eye on a bollard. The first line, the spring line, was sent ashore at 09.55 LT.

When the spring line was put on the bollard on the quay the pilot requested it to be made fast on the winch (the manual brake of the winch being set). The idea was to run the engines slowly ahead with full port rudder to bring the stern closer to the quay. The bow thruster was activated to portside. Before ordering the manoeuvre the master called out a warning to the foredeck team that the engine would be working forward and that they should seek shelter or take cover. He received a reply from the chief officer:" Yes captain - Understood".

The first attempt to bring the ship alongside failed, firstly because the spring line was slightly slacked, secondly because the engine suddenly was going astern in contradiction to the pilot's engine orders. When the pilot challenged the master on the ships maneuvers, and got the engine going ahead again, the spring line was slacked away resulting in the ship considerably passing the berthing position.

The pilot ordered the engine to go astern to get the ship back into its dedicated berthing position. This made the stern of the ship to move away from the quay as a result of the ship's maneuvering characteristics. During this maneuver the fore end line was sent ashore from the forecastle. When the ship was aft of its mooring position and still going astern, the pilot requested hard rudder to port and slow ahead, alternatively pitch 4. The engine order was eased as the vessel started to move ahead. When in position again the pilot once more ordered the spring line to be made fast and the engine put on dead slow ahead or pitch 2. The master called out a second warning to the team on the forecastle that they should seek shelter or take cover. He received a reply from the chief officer:" Yes captain - Understood".

After a while the pilot once again noted that the ship's engine was going astern and he challenged the master "why is the engine going astern?" He did not receive any answer.

The pilot once again ordered dead slow ahead or pitch 2. This time the spring line was tight, the ship remained in its position along the quay and the stern of the ship slowly came closer to the quay as a result of the hard port rudder. An aft spring line was sent ashore from the poop deck and put on a bollard on the quay. The linesman also received a second line aft.

Suddenly the spring mooring line broke. The pilot did not notice it at first but were immediately told by the master. Shortly afterwards the voice of the boatswain called over the portable VHF that the chief officer had been hit by the line and a few seconds later another call from the boatswain that the chief officer was badly injured, possibly dead. The time was estimated to be 10.20 LT.

The chief officer had been operating the control box while the boatswain was locking the winch break on his orders. When the boatswain and the able seaman went aft to take cover he noticed that the chief mate did remain at the position by the control box. The boatswain then turned back a short distance and called to the chief officer to take protection. He recalls to have shouted something like: "Chief, chief, take protection, take cover!". Then the boatswain went back to the protected place he had chosen behind the starboard winch. According to witness statements taken by the police the boatswain could see that the chief officer was manoeuvring the lines from the control box. Neither the boatswain nor the AB witnessed the chief officer being hit by the parting spring line, but they saw his helmet in the air when it came off his head.

After the accident

When the pilot was informed by the master that an accident had occurred, he asked if he should order an ambulance which the master confirmed. After mooring the ship the pilot and the master hurried forward to the forecastle where they found the chief officer lying on the deck seemingly lifeless. The pilot immediately started cardiopulmonary resuscitation (cpr).

Later on, the chief officer was moved to the area aft of the barrier while the rescue efforts were continued until the ambulance arrived. The crew of the ambulance continued the rescue attempt. At about 11.05 a.m. the ambulance doctor declared the chief officer dead. About 50 minutes had then elapsed since the alarm was received by the emergency call centre.

2.1 Ship´s crew and pilot

Members of the crew who were interviewed all spoke good English and did understand the language without difficulty. The Swedish pilot confirmed to the investigators from SHK that he did not experience any difficulties in making himself understood and did not notice any linguistic misunderstandings in his conversations with and requests to the bridge team during the manoeuvre.

During the investigation on board nothing has been found that would indicate that the mental or physical condition of any of the persons involved was reduced before the accident.

2.1.1 *Master*

The master, male, was at the occasion 49 years old and holds a master's certificate. He is a citizen of the Philippines and was educated at a national marine academy and passed his exam in 1981. He has served in national and foreign ships. By the year 2005 he got position as chief mate. By the year 2008 he became master in a Japanese ship and by the time of the accident he had served as master in the Wagenborg fleet for about one year and in M/S *Morraborg* since four months.

2.1.2 *Chief officer*

The chief mate, male, a citizen of Romania, was 55 years old and held a masters certificate. He was employed by Wagenborg via a Romanian crewing agent. He had worked in several dry cargo ships of the shipping company since September 2007. He signed on the *Morraborg* on 4 April 2011 after slightly more than three months of leave. It was his first term in this ship.

He had earlier sailed as second and first mate in dry cargo ships and container ships of other shipping companies.

2.1.3 *Boatswain*

The boatswain, male, a citizen of the Philippines, was at the occasion 48 years old. He was educated at a seamen's school in the Philippines and got his exam in 1985. He then worked in national ships and since 1989 in foreign ships. Since 2008 he has worked in four ships belonging to Wagenborg and at the occasion he had worked in M/S *Morraborg* since three months.

2.1.4 *Apprentice*

The apprentice, male, a citizen of the Philippines was at the occasion 20 years old and educated at a national marine academy. He had not yet taken his degree, but was on board as apprentice on a one year contract with Wagenborg shipping. He had been on board since 10 months. During the first three months the chief officer had acted as his mentor, then the 2:nd officer for three month and thereafter the master had been his mentor. During the time the master had been his mentor he had acted as helmsman at some occasions.

2.1.5 *Pilot*

The pilot, male, a Swedish citizen was at the occasion 45 years old and held a master's certificate. He is a licensed pilot since 2006 and has full pilot certificate for fairways and ports of Holmsund, Örnsköldsvik and several other ports along the northern coast of Sweden. He has piloted several hundred ships in the area including sister ships to *Morraborg*. However this was the first time for him to pilot the *Morraborg*. Earlier he had worked as chief officer in ocean going ships.

2.2 The ship's manouvres

The linesmen on the quay have stated that they perceived the ship's maneuvers as quite forceful. They could find some explanation to that in the strong wind, but still both of them reacted on the amount of force used in the maneuvers.

In the interview with the pilot in July 2011, he stated that he never used more than pitch 1-2 ahead, which he believed was about 20% of the full speed. And at one occasion he asked the captain for 25% speed, which according to the captain corresponded to pitch 2,5.

The pilot stated in the second interview, more than a year after the accident, that he never used more than pitch 4 ahead and then only when giving engine kicks in conjunction with hard port rudder to maneuver the stern closer to the quay. This was according to him done while the ship was moving astern or still with a slack spring line. When the spring line was under load he stated that he did not use more than pitch 2 ahead.

In the second interview the pilot also said that he assumed that pitch 2 corresponded to "dead slow ahead" and pitch 4 corresponded to "slow ahead". This assumption was based on his experience of the sister ships to *Morraborg* that he had piloted previously.

The pilot card posted on the bridge of *Morraborg* shows, however, a different correlation between pitch and engine orders. According to the pilot card pitch 1 (.10) corresponds to "dead slow ahead" and a speed of 3 knots, pitch 2 corresponds to "slow ahead" at a speed of 7 knots and pitch 4 corresponds to "half ahead" at a speed of 10 knots.

Main Engine : 5280 KW (7080 HP) SWD 8L38 8 cilinders 4 stroke diesel
Bow Thruster : 600 KW (800 HP) Variable electric pitch propeller,4 blades
Propeller Main Engine: Variable Pitch, Left Handed, 4 blades
Bulbous Bow : Yes
Type of Rudder : Balance
Maximum Angle : 45 Deg., Hard-over to Hard-over : 28 sec
Manoeuvre Characteristics : Acting Right-handed (if astern bow to s.b. aft to p.s.)

Maneuvering Engine Order	Pitch	Loaded (Speed knots)	Ballast
Sea Full	.90	. 15.5	. 16.5
Full Ahead	.60	. 13.5	. 14.5
Half Ahead	.40	. 10.0	. 11.0
Slow Ahead	.20	. 7.0	. 8.0
Dead Slow Ahead	.10	. 3.0	. 4.0
Dead Slow Astern	.10	Time Limit Astern : 50 sec	
Slow Astern	.20	Full Ahead to Astern : 120 sec	
Half Astern	.40	Minimum Pitch : 3 knots	
Full astern	.60	Astern Power : 80 % Ahead	

Figure 4. Detail from Pilot card

2.3 Forecastle – mooring arrangement

The forecastle is separated from the cargo deck area by a high barrier or transverse bulkhead. The bulkhead is situated on the forecastle, leaving a limited area for the mooring station.

The barrier is high enough to block out the view from the bridge towards the forecastle deck. Thus a person on the bridge cannot see those working on the forecastle deck. There are openings on both starboard and port side through the barrier to the walkways along the hatches.

The working space between winches, pedestals and bulwark is restricted. The distance is about one meter between the remote control unit with the platform where the person supervising the mooring is supposed to stand, and the pedestal fairleads. The remote control unit was fitted when the ship was built. The area of the remote control unit and the platform is within the immediate snap back area from the spring line. There are no markings on the deck of potential snap back zones.

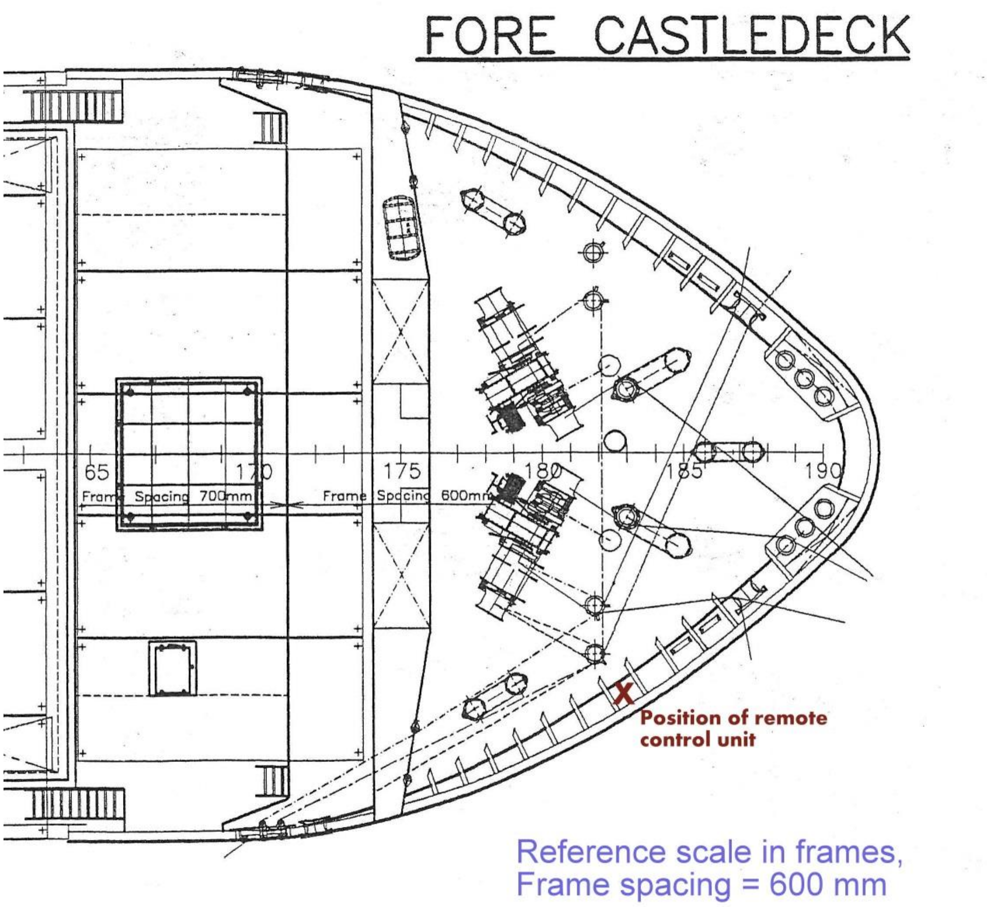


Figure 5, Drawing of forecastle deck showing position of windlasses and general mooring patterns.

On the forecastle there are two electro-hydraulic combined windlasses and mooring winches, each with storage drum, winch drum and a drum end. Manufacturer is Ten Horn Winches.

The winches have a pulling force of 8 tons on the first layer and holding force of 24 tons. The windlass can also be locked by manual band brakes on the winches. The manual breaks are of a type making it possible to adjust the maximum breaking capacity. There was no on board routine for control or adjustment of the break capacity.

Each mooring winch can be operated either from control levers on the windlass or from a remote control unit mounted in a box on the bulwark. Nearby the box there is an elevated platform for the operator in order for him to have a view over the bulwark e.g. downwards to the quay.

Fig. 6, Forecastle deck. To the right: the position of the chief officer when the accident occurred in the area of the platform at the remote control unit. To the left; the remaining of the parted spring line, piled up at its winch drum. It should be noted that the displayed configuration of the lines was made to moor the vessel after the accident and thus no representation of the common configuration used.

Fig.7, Forecastle deck, opposite direction. Through the opening in the bulkhead the spring line roller fairlead can be seen. It is likely that the spring line was lead over both of the pedestal fairleads seen in the middle of the picture. According to the pilot this was, despite the difference in height of the fairleads, the common way to run the spring line in the vessel series that Morraborg belonged to.

On the occasion the mooring rope of the starboard winch drum was used as a spring line. From the winch the rope was led over one or two pedestal fairleads, through a roller fairlead mounted in the bulwark, and down to a bollard on the quay. In the roller fairlead the rope run through a rectangular space between four rollers - two horizontal and two vertical. There were no sharp corners and the bends of the rope were not excessively sharp.

When the ship was in position and the rope had been tightened the position of the bollard was about 20 meters aft of the roller fairlead.

In the area between the two sets of bitts and the anchor hawse pipes, there were piles of mooring lines restricting the access to that area when entering in to the port of Holmsund (see Fig. 6).

2.4 Mooring line

The mooring line was a Tipto Eight rope from Lankhorst ropes. It is described in the certificate as an 8-stand plaited rope made of bi-component fibres of polypropylene and polyethylene. The rope had a nominal diameter of 52 mm and eight strands. Minimum breaking load (MLB) is specified as 441 kilonewton (kN) corresponding to about 45 tons. The value refers to a new rope. The Tipto Eight rope is the weakest rope of equivalent diameter offered by the manufacturer.

The elongation of a Tipto Eight rope is up to 22% before breaking, according to the manufacturer. This is a quite high value in comparison with other types of mooring ropes. The melting point of the rope is 135 °C.

The manufacturer have made TCLL test (Thousand Cycle Load Level) of four different types of mooring ropes they are manufacturing. The test was made under the supervision of Lloyd's Register. The TCLL test expresses the maximum percentage of the nominal breaking strength that a rope can be cycle loaded one thousand times. The TCLL value expresses the rope's resistance to tension-tension fatigue. The Tipto Eight rope had a TCLL of 70,7%, being the lowest value in the test series. (See appendix 2)

According to the crew the rope had been used on board since six months.

During their technical investigation on board the police had cut off parts of the rope, one section on each side of the fracture. The character of the fracture is "torn and threadbare". On the part of the rope coming from the winch there was a knot which was not tightened. The boatswain explained that he and the able seaman made the knot, a bowline, in order to send the rope ashore again to complete the mooring, but finally they choose to use another rope for the purpose.

After the accident the torn rope with the bowline ended up lying in a pile close to the bulwark. The eye of the bowline was partly concealed in the pile resulting in problems for the police to identify where to cut the rope. They then cut the rope at four positions in order to retain both the fracture and the knot.

Figure 8, quay side part of the parted spring line

Photographs taken by the police show the quay side part of the fractured rope collected/piled up close to the bollard. The amount of rope in the photograph indicates that the fracture most presumably occurred at the roller fairlead.

There has been no expert examination or any test performed on the parted mooring line.

2.5 Inspections, maintenance

No information has been collected on any routines for the inspection of, or any planned maintenance schedule for, mooring lines and wind lasses on board *Morraborg*.

The company has stated that there were no schedules for shifting or replacing mooring lines onboard their ships. It is not known if there was any inspection and maintenance schedule for the mooring equipment, however, it has been established that there were no routines for inspection and adjustment of winch breaks.

2.6 Meteorological information

According to SMHI (Swedish Meteorological and Hydrological Institute) the weather in the morning of 3 July was bright with no precipitation and good visibility. Late on the previous evening of 2 July a cold front had passed the town of Umeå and in the morning of 3 July it was positioned over Finland. Behind the front the wind was at times brisk with strong gusts from the north over the strait of Kvarken.

Based on reports from several wind instruments in the area SMHI estimated the average wind speed between 08.00 and 12.00 a.m. in port of Holmsund to be 7-9 m/s with gusts of 12-14 m/s. The direction was from NE at about 40 degrees.

This information is in line with the assessment of the pilot, which he told SHK about during the interview. He was standing on the starboard bridge wing during the docking manoeuvre.

There was no significant current in the area at the time.

2.7 Medical information

During the investigation nothing has been found to indicate that the physical or mental condition of master or crew members was impaired before or during the mooring operation.

The Swedish Transport Agency, who did a Port State Control inspection of the vessel after the accident found, however, that no record of rest hours was kept on board.

After the accident, on 5 July 2011, a post mortem was performed on the body of the chief officer at the Swedish National Board of Forensic Medicine Department of forensic medicine, Umeå. The report concluded that the injuries he sustained from the snap back of the parting spring line caused his death.

2.8 Shipping company – organisation

Owner of *Morraborg* is the shipping company Wagenborg Shipping BV based in Delfzijl, Holland. The Dutch Safety Board (DSB), as the authority of a substantially interested state has provided assistance by interviewing the Designated Person Ashore (DPA) of the company. The intention was to collect information about the organisation and how the company deals with safety matters.

Wagenborg Shipping owns 60-65 ships, mainly dry cargo ships, most of them gearless (without loading/unloading gear such as cranes). Ships are being built in series, mostly to shipyard's design. Wagenborg Shipping does not have its own design department.

Morraborg is one of the first ships in a series of dry cargo ships of about 9000 dwt built at Dutch shipyards. Of this series 11 ships were built for Wagenborg Shipping BV.

Wagenborg Shipping is a full service shipping company trading their own fleet. The company also offers services to external one-ship companies so called "captain owners".

Wagenborg Shipping is ISM certified since 1996 and holds certificate for ISO: 9000 since 1994 and ISO: 14000 since 1997. There is a quality control department, QAD, with three permanent employees and a number of superintendents performing audits of the ships in the owned fleet. The company SMS (Safety management system in accordance with the ISM-Code) has been approved by Lloyd's Register.

Operational instructions are described in the Shipboard Operational Manual (SOM). These manuals differ for different series of vessels. General safety instructions are included in the SOM together with reference to more specific safety instructions in manufacturers' manuals.

The company did not have a specific procedure for mooring work within their SOM. However a brief guideline was available on board the ships, "Mooring and unmooring" published by the social partners Nautilus International (union for maritime professionals) and the KVNR (Royal association of Netherlands Shipowners).

Following the Dutch Working Conditions Act 2002 risk analyses must be made for potentially dangerous types of work. Wagenborg Shipping engaged external expertise to make risk analyses of the fleet for this purpose the same year. The study was generic and the risk analyses did not identify mooring as a hazardous operation. The company's DPA stated that Wagenborg shipping BV had not had any previous fatal mooring accidents. However, he knew that mooring lines break occasionally, but had no record on how often it occurred within the company's fleet.

In 2010 a new risk analysis was ordered by Wagenborg Shipping, this time with a separate analysis for every ship. The risk analysis is on-going and is supposed to be completed before the new Maritime Labour Convention (MLC 2006) enters into force in 2013. The *Morraborg* was inspected for this purpose shortly after the accident, as a part of the scheduled risk analysis programme. Mooring remained unidentified as a hazardous operation within the risk analyses made until the accident on board the *Morraborg*.

The bridge control box used for the ship's maneuvering is similar to those on other ships of the same series as Morraborg. According to the company it is unusual that the bridge control boxes are malfunctioning. However, not all masters like to use them.

2.9 Actions taken after the accident

Wagenborg Shipping informed the other vessels in the company fleet of the accident via e-mail and via an article in the bimonthly safety bulletin "Fleet News". The information included instructions that mooring and unmooring, including snap-back zones, safety sheets and Videotel, must be discussed in the Safety Committee meetings on board.

Wagenborg Shipping also investigated the accident to determine what the company could do to improve mooring safety. No report has, however, been provided. As stated in interviews Wagenborg Shipping does not believe that improvements with regard to safety can be found in the design of the vessel or the layout of the mooring station, neither in defining safe/not safe areas. The remote control unit is, according to the company, placed in a convenient position where it is possible to monitor what you are doing. The company keeps no record on how often mooring lines breaks and has no opinion on the quality of the type of mooring line in use on *Morraborg*. The conclusion of the company's investigation was that mooring is a hazardous work, despite any efforts, and that it is important that the crew is aware of this and follow instructions to take shelter when appropriate. Hence no technical changes have been suggested or implemented by the company as a result of the accident and the subsequent company investigation. The SOM-manual has, however, been updated with a new routine that requires a safety briefing to be held with all involved personnel before any mooring or unmooring operation, using a specific check list. The officer in charge is responsible for the conduct of the safety briefing which should also be noted in an applicable log book.

The company has also established in its procedures that the company's organization ashore must check whether the (S)-VDR recorded data has been saved when a casualty is reported.

The Maritime Coastguard Agency, UK, will review their mooring instructions in the light of this report to evaluate if the instructions are sufficiently clear and unambiguous about the full extent of snap-back areas.

2.10 Rules and regulations

2.10.1 Design of mooring stations

There are no international safety regulations specifically dealing with mooring ergonomics or mooring work. The Maritime Labour Convention (MLC 2006) contains a general formulation on seafarers' safety at work in Article IV:

"1. Every seafarer has the right to a safe and secure workplace that complies with safety standards."

MLC 2006 does not contain any general rules on how the mooring workplace should be designed to be safe. Instead, reference is made to international and national regulations and standards.

Safety of Life at Sea, SOLAS, contains very general technical requirements for mooring equipment and the strength of their attachment to the ship. These regulations are similar to the common class rules that IACS issues. The latter is, however, more detailed.

IACS also imposes the requirement that the equipment should be described in a mooring plan, which will also tell how mooring lines are supposed to be arranged from the mooring equipment, via different leads and over the ship's side. Neither SOLAS nor IACS requirements include the design or lay out of a mooring station from an operational and practical safety perspective. The IACS rules contain, however, technical guidance for mooring winch breaks:

2.3.1 "Each winch should be fitted with drum brakes the strength of which is sufficient to prevent unreeling of the mooring line when the rope tension is equal to 80 percent of the breaking strength of the rope as fitted on the first layer."

2.10.2 Mooring work

Regarding mooring operations some guidelines are issued in the ILO publication ”Accident prevention on board ship at sea and in port”, 1996, (available onboard *Morraborg*) that gives basic advice, some in matters relevant to this accident:

“19.4.2. A competent person should be in charge of mooring operations and ascertain that there are no persons in a dangerous position before any heaving or letting go operation is commenced.”

“19.4.8. Ropes and wires are frequently under strain during mooring operations and seafarers should, as much as possible, always stand in a place of safety from whiplash should ropes or wires break.”

The International Safety Management Code (ISM-code) contains general rules for education of personnel in safe work on board including instructions for handling equipment and machinery in order to avoid accidents and injuries. The safety management objectives of the companies should, according to the ISM-Code, provide for safe practises in ship operation and a safe working environment, establish safeguards for all identified risks and constantly improve safety management skills. The company shall also investigate and analyse accidents with the objective of improving safety and pollution prevention.

In addition to the requirements in the ISM- code the company has to follow requirements of the national Dutch Working Conditions Act.

Working Conditions Act

The Working Conditions Act in the Netherlands (*Arbeidsomstandighedenwet*) applies to all organisations that employ staff and regulates the improvement of working conditions, the aim of which is to promote employee health, safety and welfare. The Act focuses on both the employer and the employee.

Employers are required to ensure work-related health and safety of their employees and are therefore obliged to implement a policy aimed at achieving the best possible working conditions. Work may not have any negative effect on employee health and safety, the dangers and risks facing employees are required to be prevented or limited as far as possible and effective measures must be taken in the event of accidents, fire and evacuation. Employers are required to set out the risks in a written hazard identification and analysis (Dutch: Risico-Inventarisatie en Evaluatie, RI&E), including the dangers and risk-mitigation measures. Employers must ensure that the work to be carried out and the related risks are effectively communicated to employees. Employees also have a right to effective training tailored to their distinct tasks.

Employees are obliged to take due care in relation to the work and to do their best, in line with their education/training and the instructions given by the employer, to ensure their own health and safety and that of other persons.

The Working Conditions Act contains rules to enhance safety, but leaves room to achieve this through specific and tailor-made actions. Such actions may be described in Labour catalogues (Arbocatalogus), a document set up by employers and employees in a certain industry, or their respective associations. Once approved by the Labour Inspectorate and implemented in the daily routines, the inspection and enforcement agencies will consider the document as starting point and not make additional requirements. The Labour Inspectorate approves catalogues on the basis of a quick scan with regard to the requirements from the Working Conditions Act and on the basis of followed procedures during the development of the document so as to assure that both employers and employees, or their associations, are represented.

The mooring instructions available on board *Morraborg* - KVNR, Koninklijke Vereniging van Nederlandse Reders, Nautilus Publication no D101“ Mooring and unmooring” – is a part of the Arbocatalogus.

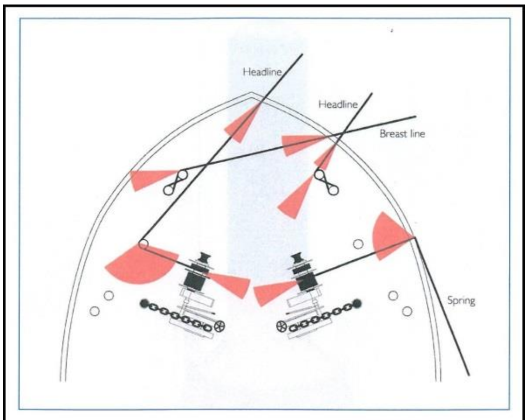


Figure 3 – An Actual Mooring Deck Arrangement Illustrating Potential “Snap-Back” Zones

- Figure 9, Description in the labour catalogue of potential snap back zones on a forecastle. The illustration is also found in, and is origin from, The Code of safe working practises for merchant seamen, 2009. Maritime Coastguard Agency, UK
-

According to the labour catalogue the “Officers in charge should have an overall picture of the situation at all times”

2.11 Industrial standards

A number of institutions in shipping have published guides for safe mooring work. The most elaborate publications describe the functioning of winches, characteristics of wires and ropes of different materials, mooring forces under different conditions and dangerous working moments. They also contain guidance for how to perform different tasks in a safe manner and warnings for dangerous mistakes. Some of the more recognized guidelines are:

- The Steamship Mutual Underwriting Association (Bermuda) Ltd "The mooring series – Edition 2" (Available on board *Morraborg*)
- Mooring and Anchoring – Principles and Practice, 2009, Nautical Institute
- Code of safe working practises for merchant seamen, 2009. Maritime Coastguard Agency, UK
- Mooring equipment guidelines - Editions 1992, 1997 and 2008 – Oil Companies International Maritime forum (OCIMF)¨

A new mooring guideline has also been issued in recent years;

Mooring – Do it safely! A guideline issued in 2013 by Seahealth in Denmark. Available on the Internet. http://www.seahealth.dk/en

3. ANALYSIS

Mooring work is potentially dangerous and is a type of work where accidents occur, sometimes with fatal consequences. When moorings are overloaded and ropes or wires part, substantial elastic energy can be transported at high speed along the working area. The risks associated with mooring work is well documented in accident investigations and guidelines issued by different maritime organizations.

The technical regulations on mooring equipment (e.g. windlasses) and its design are all focused on the strength of the equipment and the strength of their attachment to the ship. The very few rules in SOLAS are all based on the IACS standards. There are, however, no international requirements on how a mooring station should be arranged to provide a safe work environment.

The *Morraborg* has been sold from Wagenborg Shipping BV since the accident occurred, but there are several sister ships with a similar or identical design still in the company's possession.

3.1 Berthing

The method to take a ship alongside by running the engines against a spring line has been commonly used in smaller ships in coastal trading for many years. Over the years the ship sizes have increased and in general also the manoeuvre-ability of the ships.

The design strength of a ship's moorings is based on the moorings ability to resist the maximum static load to hold the ship secure alongside, with an adequate safety factor. The moorings possible use in assisting the maneuvering of the ship to the berth is not taken into account. The quality and characteristics of the moorings may therefore need further considerations before they are used this way.

The *Morraborg* was not equipped with stern thrusters and had a high deck load enabling wind forces acting on the ship. Without the support from a stern thruster or a highly efficient rudder, or a tug boat, more engine power was needed to bring the ship alongside the quay, putting equally more force on the spring line.

There are some circumstances indicating that the cooperation on the bridge was not optimal and that vital equipment on the bridge, for unclear reasons, was not being used for the berthing (e.g. the bridge control box and indicator panel).

The use of the bridge control box would have facilitated the berthing by enabling more precise engine orders, shortened the time for different maneuvers to be executed, and by avoiding any potential misunderstanding in engine orders.

Without the bridge control box and the indicator panel the pilot had no available rudder and engine indicators at his position on the bridge wing to control the amount of rudder or engine applied at a given moment. His orders were repeated back to him by the master when first heard but not a second time when executed, leaving the pilot without any confirmation that his orders had been correctly executed. Twice he found the engine going astern in direct contradiction to the orders he had given.

The pilot, on the other hand, sometimes gave the engine orders in terms of a required pitch, rather than the more traditional command structures "dead slow ahead", "slow ahead", etc., without ascertaining what pitch corresponded with what engine order. Neither did he ascertain how much engine a certain order would give. This might have resulted in that the pilot consequently requested harder maneuvers than he intended. What engine orders were requested, or in what manner the engine order was requested at the time the spring line parted, has not been possible to establish. Neither has it been possible to determine the capability of the apprentice to execute the right orders, even though it can be questioned if such qualified tasks should be given to a trainee.

The fact that the pilot was not having direct access to controls and indicators of the ship from his position, made the interface for the pilot very coarse, inefficient and extremely slow to react. It made quick and minor adjustments difficult to execute. It also put a high demand on the master’s, apprentice’s and pilot’s ability to understand and co-operate with one another. Some indications, such as the engine going astern when ordered ahead, show that this demand was too high at some points, and that contradicting orders might have been given along the chain of communication.

3.2 Why did the chief officer remain within the immediate snap-back area?

It is not known what training the chief officer had had when it came to mooring operations and risks connected with mooring, but since he was an experienced seaman it could be assumed that he had some sort of understanding of the risk he took by remaining at his position by the bulwark when the master called out the warning. It is therefore more likely that other factors than lack of knowledge contributed to his decision not to move to a safer place.

To perform his task to lead the mooring operation on the forecastle he needed to have an overview of the vessel’s movements along the quayside, as well as over the tightness of the mooring ropes, an overview that he could only get from the starboard side of the forecastle. Even if the spring line was made fast at the mooring winch, the fore line that previously had been sent ashore still needed to be monitored and perhaps also operated from the control box (e.g. slacked out) to enable the ship to come fully alongside.

The fact that the chief officer stayed at his post during the sequence of events is seemingly a perceptive decision, even though the chief officer was given specific orders to move to safer position. In an alarming situation, when there is an immediate risk, a natural response can be to get to a safer area. Although it is likely, since a line breakage is not a common occurrence on a ship, for a crew member to perceive that the actual risk is minimal. Therefore a decision to stay at ones post, in the interest of bringing the ship safely to the quay, is likely to outweigh the perceived risk of the lines breaking.

Adding to this were the orders and actions taken by the pilot, master and apprentice on the bridge. What from the beginning was expected to be a quite simple mooring situation developed to be a more complex situation for the team at the forecastle. The difficulties to bring the ship in position made it even more important for the chief officer to have a clear view over the ship's movements, not only for his own safety, but for the safety of the ship and his team members on the forecastle.

The chief officer of the *Morraborg* also had few options to safely move away from the position where he was standing when the master called out his warnings. The spring line blocked his escape to the aft and the fore end line blocked his escape forward. The way he possibly could leave the area was over or around the set of bitts by the starboard hawse pipe, stepping in piles of ropes and passing in the narrow gap between the two free drum ends of the windlasses.

It is the conclusion of SHK that the poor layout of the forecastle mooring station and the lack of a safe position for supervision of the mooring operation to a great extent contributed to the fact that the chief officer remained in the snap back area despite the master's warning.

3.3 Fore deck arrangements and ergonomics

The high bulwark fore of the cargo space left a very limited space for the mooring arrangements on the forecastle resulting in several disadvantages from a safety point of view.

The position of the windlasses on the forecastle, presumably a result of the limited deck area, made it necessary to lead the spring line in a sharp angle of 120 degrees over a pedestal fairlead before it could run over board through the dedicated spring line roller fairlead. The confined work space on the forecastle also made any escape out of a potentially dangerous area rather obstructive. When entering and leaving ports the deck area, as in this case, is generally restricted by piles of additional mooring ropes needed for the mooring of the vessel.

To monitor the ship's movement and the position and tightness of different lines is an essential part of the supervisory work performed by the person in charge of the mooring operation. There is a clear conflict between the personal safety of the chief officer and the general safety of the ship during the mooring work. At the position of the control box, the chief officer can monitor and manage the fore and spring lines and at the same time have a good overall view of the ship in relation to the quayside. But this position is clearly within the snap-back zones of potential line breakages. A safer position would be behind the windlasses where the lines could be managed, but that would sacrifice the ability to monitor the ship's movements in relation to the quayside. In addition, moving to the position behind the windlasses would have been problematic due to the confined space and piles of mooring ropes placed on deck area.

The forecastle, in general, and the station by the control box, in particular, being such key areas must be designed in a way to promote safe usage under several types of conditions, especially those that are vital to basic ship operations. The design falls short on a number of points, as stated above, and cannot, therefore, be said to promote safe operations. As previously mentioned there are no international rules or requirements when it comes to the layout of a mooring station from the perspective of its safe operation.

The remote control unit was already present on the *Morraborg* during building. The accident has not been a reason for Wagenborg Shipping to re-examine the design of the foredeck or the location of the remote control unit. A design problem is generally difficult to deal with when a ship is already built. However, a challenge for the Wagenborg Shipping BV will be to address the issue with a safe place for supervision of mooring operations on the forecastle of the remaining of the sister ships in their fleet with similar layout.

3.4 Mooring line and windlass

The mooring arrangement should be seen as a system and the design of the mooring system should fulfill certain criteria to be safe:

1. The winch should stall or walk back before its pull is sufficient to part the mooring line.
2. The winch break should slip or render before the load is sufficient to part the mooring line.
3. The mooring line should part at a load that is insufficient to damage the mooring equipment.

The choice of a highly stretchable mooring line onboard *Morraborg* gave the benefit of a shock-absorbing mooring but did also give the disadvantages of a mooring line that would flex more when parting. There are other mooring lines available on the market, even from the same manufacturer, that are less elastic and less prone to uncontrolled flexing when parting, that are more durable (higher TCLL-value) and, despite having the same diameter, are considerably stronger.

It is not known what routines there were onboard the *Morraborg* when it came to inspection and maintenance of the mooring equipment and mooring lines, or at what interval mooring lines were shifted or replaced. It has, however, been established that there were no routines onboard the *Morraborg* to control or adjust the winch break to slip or render at a certain load, leaving the mooring line to be the weakest link in the system.

The choice of the type of mooring line, the proper setting of the winch break maximum load, together with a proper monitoring and maintenance of the mooring equipment and mooring lines, are all essential components to maintain the system safety and reduce the risk of mooring lines parting.

3.5 Snap back areas

There are several publications available to mariners that contain misleading information on the extent of potential snap back areas. Amongst them is the publication that was available onboard *Morraborg*. The same picture occurs also in a guideline issued by the UK Maritime and Coastguard Agency, MCA. In figure 10 the snap back areas drawn are misleading in particular when it comes to the longitudinal extension of the potential snap back area.

A parting line has the potential to flex the whole distance from the place where it parts to the place where it is attached and further on, beyond the place of attachment, to its full remaining length (as seen in figure 11). The potential snap back zone is estimated to spread in an angle of 20 degrees from the point where it parts. If the line is re-directed over a pedestal fairlead the potential snap back area is extended to cover a possible re-direction of the elastic energy released when the line breaks.

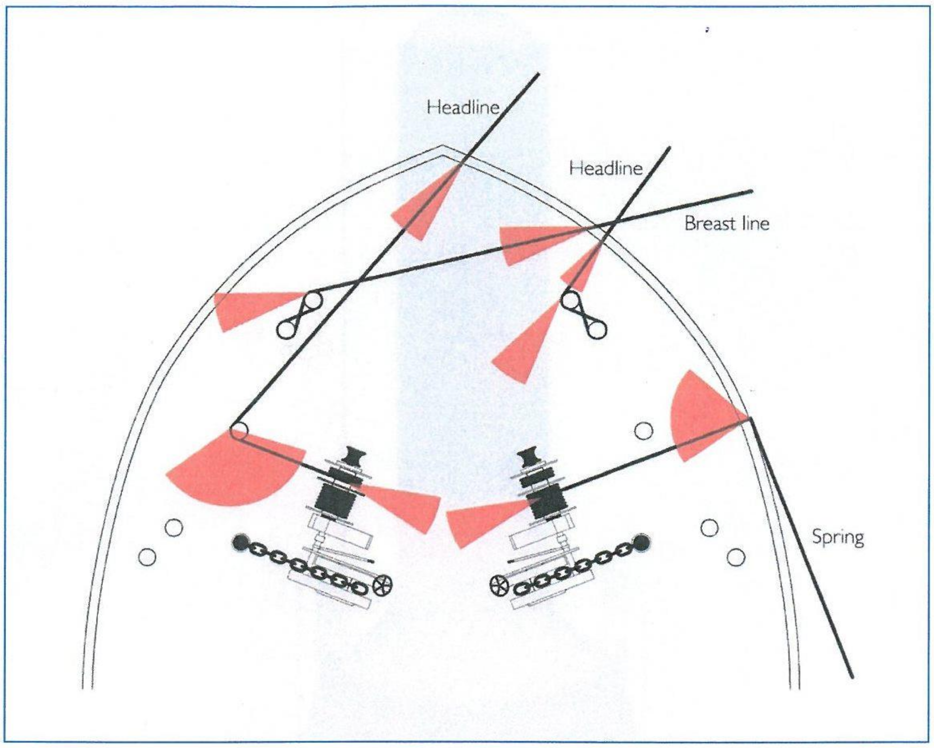


Figure 3 – An Actual Mooring Deck Arrangement Illustrating Potential "Snap-Back" Zones

Figure 10, Snap-back zones as described in instructions onboard and in some other publications.

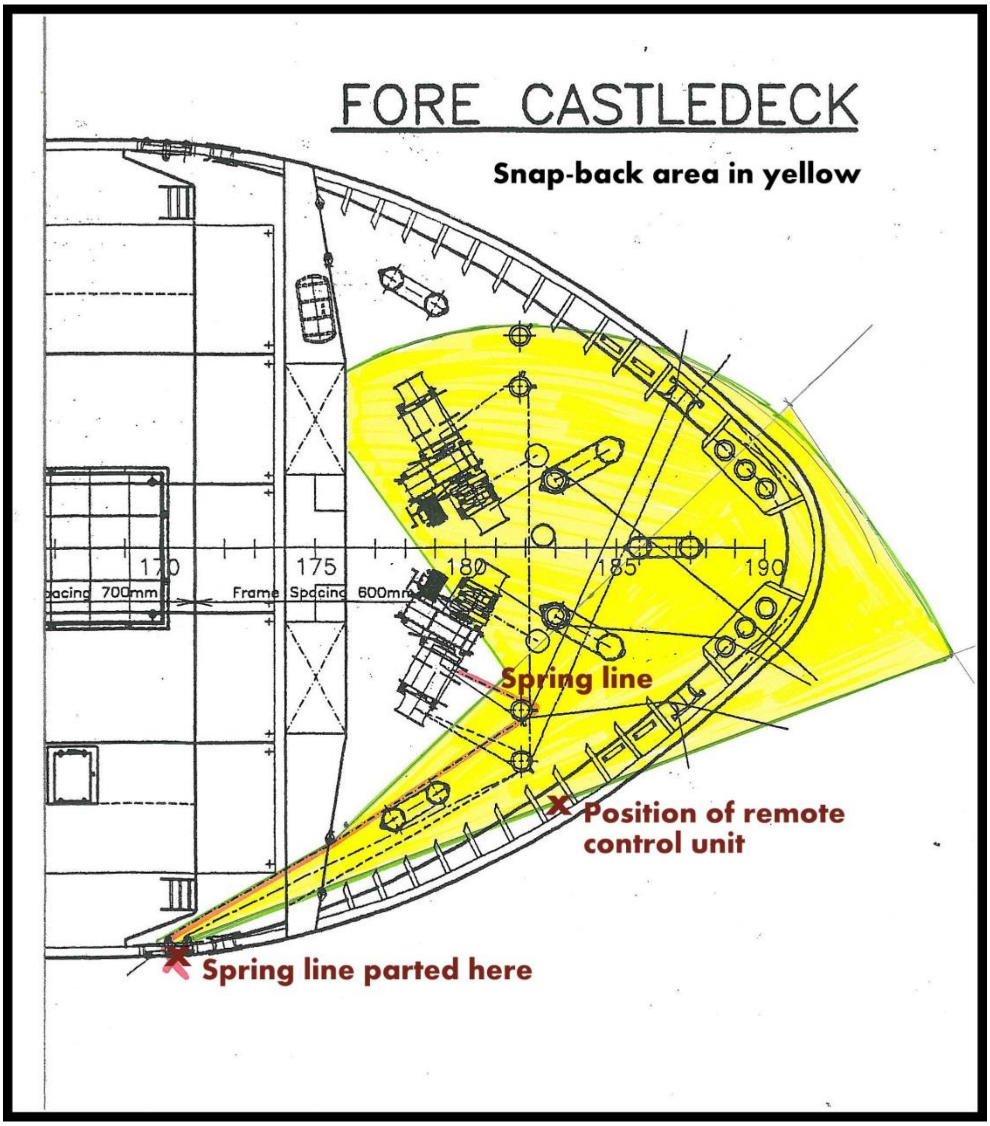


Figure 11, The calculated potential snap-back area of the spring line when parting at the spring line fairlead onboard the Morraborg when the spring line is lead only over the first pedestal fairlead.The position of the remote control unit, by which the deceased chief officer where standing, is within the immediate snap-back area. The snap back area would be increased towards the control box if both pedestal fairleads were used

3.6 Operational routines on board

During the mooring procedures, the master was engaged in several activities. This meant relaying messages between the pilot and the apprentice, and also communicating with the chief officer on the forecastle. The master also had to move between the bridge and the bridge wing to relay the messages between the pilot and apprentice and to monitor both. There was no closed loop communication between those involved; when an order was carried out it was acknowledged, but not reported back to the pilot. These activities could in combination be considered stressful, contributing to misunderstandings.

To facilitate safe maneuvering of the ship the bridge control box is essential. The statement of the master regarding the experience of the apprentice to execute all the ship's maneuvers, together with the statement of the pilot that it was not uncommon that the bridge control boxes on the sister ships of *Morraborg* were out of order or not used for maneuvering, indicates that there can be a problem within the company related to either the functionality or the usage of essential equipment on the bridge as well as weaknesses in the bridge resource management. The company claims that the bridge control box generally works but is not always used for maneuvering. This will, however, be dealt with according to the company.

When it comes to mooring routines, proper and well documented procedures for the mooring procedure as a whole, is vital to ensure a safe working environment. Procedures, generally, can be written, spoken or just implicit. There were no written procedures onboard the *Morraborg*, however, it seems like there was an agreement that the master called out warnings before putting load on the spring line.

The master and pilot had no way to visually confirm that the chief officer had carried out the order to clear the area, since the bulkhead and the bulk of the cargo hindered it. There was no closed loop communication between the master and the chief officer on the forecastle that assertained that the dangerous area actually *had* been cleared. With two issued orders to clear the area and with acknowledgement from the chief officer, the master had no reason to believe that the area was not cleared.

Procedures must apply to the specific environment and equipment. If the procedures are inadequate, too tightly coupled with specific situations, emphasized on local efficiency or even if they are overdesigned, it is likely that a crew starts adapting procedures to fit the situation, so called procedural drift.

In the specific case, the actual design of the mooring arrangement may have led to procedural drift. The obvious conflict with leaving the position by the control box (with an overall view of the situation and being able to manage the lines) and moving to a position behind the windlasses (safer but without an overall view of the ship's movements in relation to the quayside) can directly lead to an adaptation of the established and ordered procedure. The design of the mooring arrangement did not allow for the mooring work to be carried out in a safe way at the same time as the chief officer had an overall view of the mooring work. Therefore the diverging decision, i.e. not following the master's orders, can be seen in this context, where the chief officer adapted the procedure.

The Master had, on two separate occasions, ordered the chief officer to get to a safe area when putting load on the lines. Clearly, this was and cannot be considered an efficient enough barrier to prevent the events that took place. There was no other position where the chief officer could supervise the mooring procedure and at the same time manage the lines, which most likely undermined the feasibility of the orders given. The position of the control box benefited from a good overview but lacked in personal safety and the position by the wind lasses benefited from being in a safer area and from where the lines could be managed but lacked in monitoring the ship's movements in relation to the quayside. A barrier in this case must be designed to either handle the drawbacks of one position or to add a viable alternative where the same tasks could be performed safely. The order to get to a safer area did neither. For the same reason it is likely that the company's new procedure with safety briefings prior to mooring operations will have little remedial effect on this particular safety problem, even if it can contribute to enhance general safety aspects of mooring.

3.7 Company safety and mooring guidelines

There are a number of coinciding factors regarding ship safety that could be contributing factors to the events on *Morraborg*. Firstly, no written record was kept concerning the rest hours aboard ship. Therefore there is no way to conclude to what extent fatigue might have been an issue. As this event does not clearly present itself as an accident related to fatigue, there is no means of affirming or disregarding it. Secondly, the Wagenborg shipping company had not identified mooring as a hazardous work in their risk assessment conducted in 2002 and 2010, before the accident on *Morraborg*. Therefore no preventive measures could be taken into effect. There was no analysis made or any information provided to the crew regarding what areas of the forecastle deck that could be regarded as safe or not under certain circumstances. The company mooring instructions were insufficient to address the safety problems connected with mooring work onboard *Morraborg* and her sister ships.

The company claimed that they had not had any fatal mooring accident before this accident. Mooring work is, however, widely regarded as a high risk work in the maritime sector. The company had the possibility to be proactive and look at accident reports from others, new guidelines, new development, etc.

After the accident the company made an internal investigation into the accident. As a result of the investigation it was concluded that no technical changes to the mooring station or equipment where necessary.

There are, however, at least two crucial issues that need to be addressed by the company in order to prevent similar accidents in the future: The probability of parting lines and the safe position on the forecastle for supervision of the mooring operation. The first issue is related to the use and maintenance of mooring equipment, the chosen quality of mooring ropes, the bridge team management and the use of tug boats. This investigation has found that there is room for improvement in all these areas within the company. Secondly, the lack of a safe place for supervision is a design deficiency that can and should be corrected on the company's remaining vessels in the series.

3.8 (S-)VDR data

(S-)VDR data is particularly helpful in accident investigation and near miss analysis. Unfortunately no data was saved in this accident. Company instructions regarding saving of (S-)VDR data was not followed by the master. The fact that S-VDR data was not saved has hampered the investigation. The data needed for the investigation was in particular:

- Bridge communication
- Engine demand and response
- Rudder demand an response

Engine and rudder demand and response are, however, not recorded by S-VDR:s in general.

When the demand for VDR:s and S-VDR:s was introduced gradually in the years 2002-2010, this meant only a requirement to install the equipment on board. Data should, according to the technical specifications, be stored in a capsule on the bridge roof. According to the technical standards the data in the capsule is continuously overwritten with 12 hours of delay if no action is taken to save the data. If the ship sinks, however, the overwriting of data should automatically be stopped. The SOLAS requirements contain no operational requirement to manually save data in the event of an accident not leading to the ship's foundering. The operation of the equipment is instead described in a guidance document, MSC.Circ.1024 - Guidelines on Voyage Data Recorder (VDR) ownership and recovery, and hence does not have the same status.

Several casualty investigation authorities have in different accident investigation reports described problems with (S-)VDR data that is not saved by the crew in the event of an accident.

Most countries have legal requirements since long time stating that actions should be taken by the master to save the ship's log book if the ship has to be abandoned. However, it is not certain that a corresponding requirement to save data from the VDR and S-VDR has been widely introduced in national legislation since the carriage requirement came into force. Sweden introduced no such legal requirement by that time, but complemented the Maritime Code later in connection with a review of the legislation on marine casualty investigations, which entered into force in 2011. In the Netherlands, there is currently no legal requirement at all to save data in the event of an accident.

A legal requirement from the flag state would put more emphasis on the master's and company's responsibility to save VDR and S-VDR recorded data in case of a marine casualty.

4. CONCLUSIONS

It is general knowledge in the maritime industry that mooring is a hazardous operation. Risk analysis is a legal requirement in the Netherlands since 2002. Wagenborg Shipping BV had, however, not identified mooring work as a risk before the accident and had not developed procedures for safe mooring operations.

The forecastle mooring deck of *Morraborg* and her sister ships are very restricted with limited access to safe areas. Forecastle arrangement together with the limited working space makes it difficult to escape the area.

To perform his task the chief officer needed to have a good overview of the ship's movements, the tightness of different mooring lines as well as the position of the other crew members on the forecastle.

The dedicated place that enabled the chief officer to perform his duties, i.e. by the windlass remote control box and the supervision platform by starboard bulwark, is located within the immediate snap-back zone of the spring line on *Morraborg*.

The master ordered the spring line to be locked by the manual winch break. He also called out warnings to the chief officer to clear the area before he put load on the spring line.

Load tests of the manual band brakes of the windlasses were not carried out on *Morraborg*.

No visibility between the bridge and the forecastle, together with inefficient communication routines, resulted in the inability for the master to ascertain that the dangerous area had been evacuated.

The bridge control box was not used for the berthing manoeuvres for unclear reasons. Instead a trainee was put to execute all manoeuvres. Master/pilot information exchange was insufficient. Bridge communication and orders given were misunderstood or even neglected.

The linesmen on the quay found the ships manoeuvres excessive forceful.

As neither the pilot nor the master deemed it necessary, no tug was used during berthing.

The vessel was equipped with an S-VDR, but contrary to the company's shipboard operating manual procedure the S-VDR recorded data was not saved after the accident.

5. SAFETY RECOMMENDATIONS

Based on the facts and the conclusions drawn from the investigation SHK hereby recommends;

Wagenborg Shipping BV to make a more comprehensive risk analysis for mooring work at least taking into account:

- Strength and quality of mooring lines in relation to their operational use
- The potential need for tug boats to assist in mooring operations
- Scheduled inspection and maintenance of mooring lines and mooring equipment, including load test of winch manual band breaks.
- Position of winch control boxes taking into account potential snap back zones
- How to ensure the possibility to supervise the mooring operation from a safe position
- The need for operational procedures and proper communication
- How to ensure safe design of mooring stations on new built ships,

Based on the results of the analysis, establish an action plan to enhance mooring safety and take appropriate actions for existing and new built vessels. *(RS 2014:03R1)*

Sakhalin Shipping Company (SASCO), who is the present owner of the *Morraborg*, to undertake a risk analysis on mooring taking into account what is stated in (RS 2014:03 R1) for Wagenborg shipping BV, and establish an action plan to mitigate the particular risks associated with mooring operations of this vessel. *(RS 2014:03 R2)*

Wagenborg Shipping BV to review the functionality of the bridge remote control boxes on the sister ships of *Morraborg* and take any appropriate action to ensure their good operation and their use. *(RS 2014:03 R3)*

Dutch mariners union, *Dutch Shipowner association*, to consider a review issued mooring instructions with regard to the extent of snap back zones. *(RS 2014:03 R4)*

Ministry of Infrastructure and the Environment of the Netherlands to raise the issue of a legal requirement to save data from (S-)VDR in ships flying the flag of the nation. *(RS 2014:03 R5)*

The Swedish Accident Investigation Authority respectfully requests to receive, by **1 August 2014** at the latest, information regarding measures taken in response to the recommendations included in this report.

On behalf of the Swedish Accident Investigation Authority,

Jonas Bäckstrand Ylva Bexell

APPENDICES

Appendix 1, Tipto Eight product sheet

Appendix 2, Lankhorst Newsletter 1/2011

FIBRE ROPES

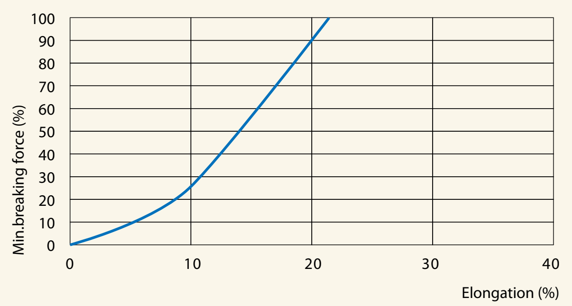
The well known high-performance mooring rope. Its strength, abrasion resistance and energy absorption ensure a long life-time and economical purchase. The small diameter and low weight make the handling on board easier.
As Tipto Eight® is floating, the risk of getting the rope into the ship and tug propeller is minimal, avoiding costly downtime.

TIPTO EIGHT®

SPECIFIC GRAVITY	• 0,93	CONSTRUCTION	• 8-strand plaited
UV-RESISTANCE	• very good	TCLL VALUE	• 70,7%
ABRASION RESISTANCE	• very good	COLOUR	• yellow
CHEMICAL RESISTANCE	• good	MARKER YARN	• orange
ELONGATION	• see graph	WATERABSORPTION	• 0%
MELTING POINT	• approx. 135°C		

Art.number	Circ. (inches)	Diameter (mm)	Weight (kg/100m)	MBF (kN)
111.693	5	40	75,6	269
111.721	5 1/2	44	92,4	321
111.695	6	48	109	378
111.737	6 1/2	52	128	441
111.697	7	56	149	508
111.698	7 1/2	60	171	578
111.699	8	64	194	651
111.700	8 1/2	68	220	731
111.701	9	72	246	814
111.703	10	80	305	992
111.735	11	88	369	1180
111.705	12	96	438	1400
111.741	13	104	515	1620
111.743	14	112	596	1870
111.691	15	120	686	2130
111.744	16	128	779	2410
111.746	17	136	880	2710
111.739	18	144	987	3030

Diameter, weight and MBF (as well as other mechanical and physical properties) are determined according ISO 2307:2005



Appendix 2

Lankhorst | Ropes

Maritime Ropes Briefing 1/2011

In our first newsletter of 2011, we focus on rope quality and the cost of rope ownership. Judging rope quality is more difficult than ever which is why Lankhorst Ropes advocates the Thousand Cycle Loading Quality Check as a guide to cost of ownership. We also announce our rope recycling scheme for Lankhorst ropes – this is an industry first and great news for all maritime companies following environmental sustainability policies.

Hans Pieter Baaij • Manager - Lankhorst Ropes Maritime Division. Email: maritime@lankhorstropes.com

Higher quality ropes last longer

Selecting higher quality rope helps to reduce rope costs, and improves rope handling and crew safety.

Tests at Lankhorst Ropes have shown that selecting ropes based on price alone can cost you up to 2.5 times the cost of an alternative higher quality rope over the same period.

continued overleaf

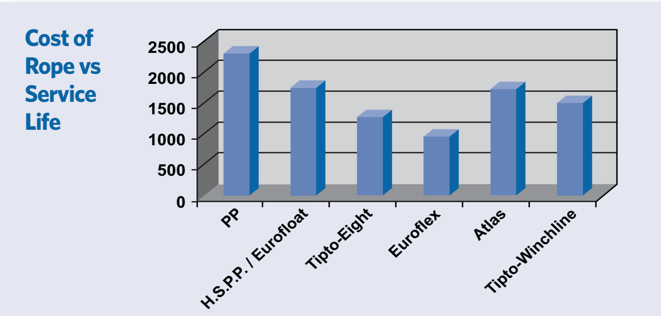
Higher quality ropes last longer *continued*

Cost of Ownership

The cost of rope ownership has to include factors such as the operational life of the rope ie the number of pulls or moorings linked to the mechanical characteristics of the rope such as abrasion and fatigue resistance, ease of rope handling and storage. The lower operational life of a low quality rope will mean it has to be replaced more frequently. When compared with other higher quality ropes, the total cost of ownership for lower quality ropes is considerably more.

For example, polypropylene has only a quarter of the life of a Euroflex rope. The cost of using and replacing polypropylene will be say 2,300 dollars compared with using a single Euroflex rope costing 900 dollars over the same time period. An additional cost of 1,400 dollars with polypropylene, and this doesn't take into account the cost of ordering new rope, and replacing and disposal of the old rope.

The following chart shows the cost of ownership for a range of ropes:



Thousand Cycle Loading Quality Check

A good insight into the quality of mooring ropes is the Thousand Cycle Load Level (TCLL) value. TCLL expresses the maximum % of the nominal breaking strength that a rope can be cycle loaded one thousand times, tested under strict conditions. Put simply, the TCLL value expresses the rope's resistance to tension-tension fatigue. The higher the TCLL value, the greater the resistance to high cycle loads.

The TCLL value originates from the Oil Companies International Marine Forum (OCIMF) guidelines for single point mooring hawsers for the safe mooring of tankers. The OCIMF guidelines set an important benchmark for mooring ropes. At present national rope standards tend to be very basic and do not guarantee any quality.

And although OCIMF guidelines are used by tanker operators, the TCLL data can also be extrapolated and applied to other types of seagoing vessels.

Under supervision by Lloyd's Register of Shipping, the TCLL value has been determined for the following ropes:

Tipto-eight – 70.7%
Eurofloat – 73%
Euroflex – 79.6%
LankoForce – 100%

Compared with polypropylene with TCLL 52% and polyamide based ropes, the Lankhorst ropes will have significantly longer operational life.

Rope Recycling Scheme gets underway

Lankhorst Ropes has announced the rope industry's first recycling scheme for retired maritime ropes. The ropes are recycled and may be used as an ingredient for picnic sets, plastic poles, planks and even complete landing stages, riverbank protection boards and bridges.

Traditional natural yarn ropes have long been superseded by stronger and lighter synthetic yarn fibre ropes such as polyester and polypropylene in maritime towing and mooring. Until now the industry lacked a systematic approach to recycling used ropes.

'Cradle to Grave' Rope Care

Developed over the past 12 months, the Lankhorst Ropes scheme takes a 'cradle to grave' approach to rope recycling for its maritime customers. New ropes are supplied with a works certificate containing the rope's unique number and recycling scheme logo. When ropes are returned, a confirmation of receipt for recycling is issued.

For customers following Green and sustainability policies in other areas of their business, the Lankhorst Ropes' ropes recycling scheme now allows mooring and towing ropes to be included in these policies.

The following Lankhorst maritime ropes are included in the recycling programme: Tipto, HSPP, Euroflex, Eurofloat and Strongline.

Exhibition Diary

7-9 April, shipbuilding, machinery & marine (SMM) show in Mumbai, hall 5, booth B34; to see the latest Lankhorst Ropes developments in stronger, longer lasting and easier to handle maritime ropes.

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