Bundesstelle für Seeunfalluntersuchung
Federal Bureau of Maritime Casualty Investigation
Federal Higher Authority subordinated to the Ministry of Transport,
Building and Urban Development

Investigation Report 557/08

Very Serious Marine Casualty

Fatal accident caused by a mooring line of the TMV COVADONGA breaking on 28 October 2008 in Brunsbüttel Lock

1 October 2010

The investigation was conducted in conformity with the law to improve safety of shipping by investigating marine casualties and other incidents (Maritime Safety Investigation Law - SUG) of 16 June 2002.

According to said act, the sole objective of this investigation is to prevent future accidents and malfunctions. This investigation does not serve to ascertain fault, liability or claims.

This report should not be used in court proceedings or proceedings of the Maritime Board. Reference is made to art. 19 para. 4 SUG.

The German text shall prevail in the interpretation of this Investigation Report.

Issued by:
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1 Summary of the marine casualty

At about 1900[1] on 28 October 2008, the TMV COVADONGA was made fast on her port side in the Große Südschleuse (large southern lock) in Brunsbüttel with head line, fore spring and stern line. After the lock gate in the direction of the Elbe was opened, the TMV LISTER, which was moored on the opposite side, was the first vessel to sail out of the lock.
When she sailed past at about 1913, the fore spring of the TMV COVADONGA broke. A person who was working as linesman[2] in close proximity on the lock wall was struck by the line and thrown into the water. In spite of immediately initiated rescue attempts, the linesman succumbed to his injuries at the scene of the accident.

[1] All times shown in this report are Central European Time CET = Universal Time Coordinated (UTC) + 1
[2] Designation of the Waterways and Shipping Authority (WSA) for linesmen = Lock Deckhand

2 SHIP PARTICULARS

2.1 Photo

Hasenpusch Photo-Productions

Figure 1: Photo

2.2 Vessel particulars

Name of vessel:	COVADONGA
Type of vessel:	Motor tanker/chemical tanker
Nationality/flag:	Portugal
Port of registry:	Madeira
IMO number:	9300489
Call sign:	CQMQ
Owner:	Cecilia Maritime S.A.
Year built:	2005
Shipyard/yard number:	Tuzla Gemi – Istanbul/No. 25
Classification society:	Lloyd’s Register of Shipping (LR)
Length overall:	119.10 m
Breadth overall:	17.10 m
Gross tonnage:	4,816
Displacement:	9,947.90 t
Deadweight:	6,967.58 t
Draught (max.):	8.40 m
Engine rating:	4,440 kW
Main engine:	MAN / B&W, Type: 6S35MC, controllable pitch propeller
(Service) Speed:	13.5 kts
Hull material:	Steel
Hull design:	Double bottom and hull

2.3 Voyage particulars

Port of departure:	Szczecin, Poland
Port of call:	Aviles, Spain
Type of voyage:	Merchant shipping/international
Cargo information:	Dangerous cargo, 6,321.64 t of distillates
Manning:	14
Draught at time of accident:	Fore = 6.65 m, amidships = 6.74 m, aft = 6.82 m
Pilot on board:	Yes, 1
Canal helmsman:	No
Number of passengers:	1

2.4 Marine casualty or incident information

Type of event:	Very serious marine casualty (VSMC):
Date/Time:	28 October 2008/1913
Location:	Brunsbüttel, Große Südschleuse
Latitude/Longitude:	φ 53°53.7' N λ 009°08.6'E
Ship operation and voyage segment:	Prior to casting off
Place on board:	N/A, linesman was struck on shore
Consequences:	Fatal injury

Excerpt from nautical chart BSH, Pleasure Craft Chart 3010, Chart 4

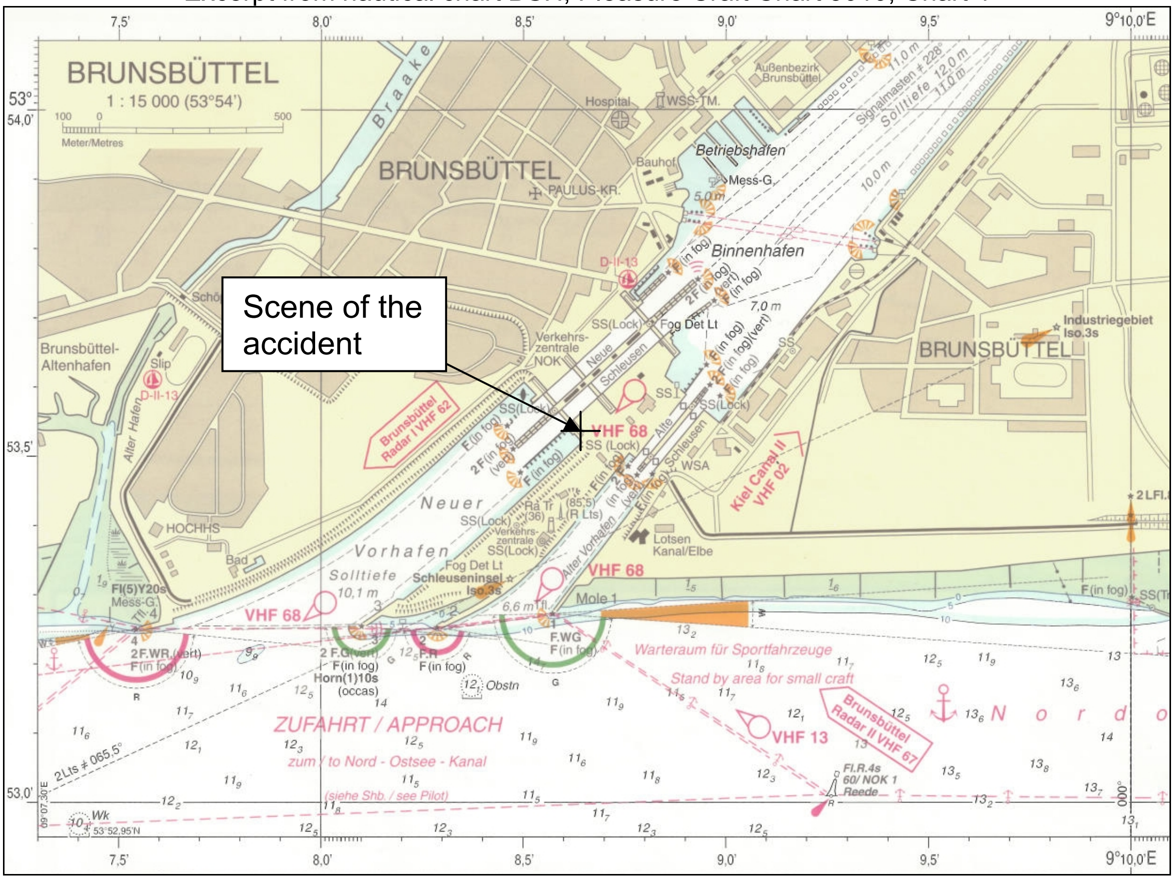


Figure 2: Nautical chart

2.5 Shore authority involvement and emergency response

Agencies involved:	WSP, WSA, emergency doctor and paramedic, Brunsbüttel Fire Brigade
Resources used:	Shipboard crane to recover the body
Actions taken:	Recovery from water and resuscitation attempts
Results achieved:	The casualty succumbed to his injuries

3 COURSE OF THE ACCIDENT AND INVESTIGATION

3.1 Course of the accident

On 28 October 2008 during the period from 1826 to 1848, four vessels entered the lock chamber of the Große Südschleuse in Brunsbüttel, all were headed for the Elbe.
As the first vessel, the TMV LISTER, length 133 m, breadth 19 m, draught 7.40 m, loaded with 7,482 t of acid, made fast on the middle wall abreast of the control station. The second vessel to enter was the TMV COVADONGA. She made fast in front on the outer wall with her head line, fore spring and stern line; however, the aft spring was not used. The TMV COVADONGA was followed by the MV SUOYARVI, length 81 m, breadth 11 m and after her the MV ACAVUS, length 127.2 m, breadth 20.4 m entered. The drawing below was submitted to the BSU and shows the position of the vessels in the lock. The MV ACAVUS is incorrectly shown as the ACARUS and the drawing of the head and stern line guidance of the COVADONGA does not correspond with witness accounts (see sub-para. 3.2.9.4 and Fig. 35)

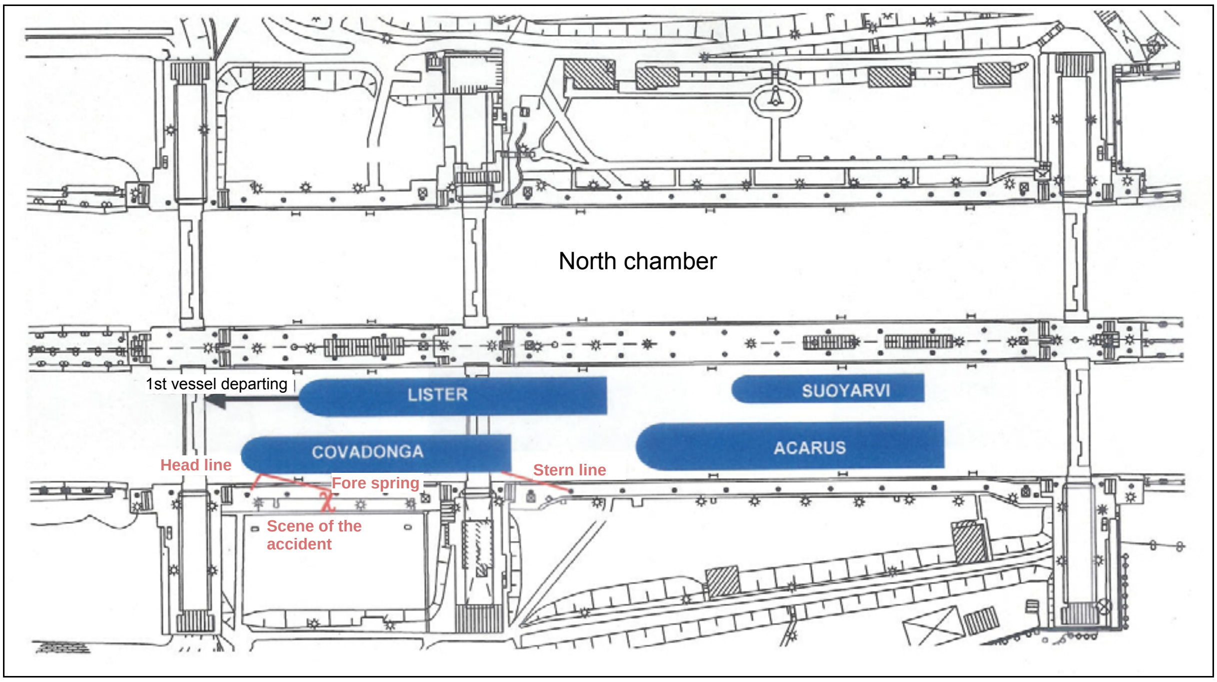


Figure 3: Position of the vessels in the lock

After the lock gate to the Elbe was opened, the TMV LISTER was the first vessel to sail out at about 1912 after consulting with the lock master; she was to be followed by the TMV COVADONGA.
After the lines were cast off, the TMV LISTER proceeded. As the aft ship of the TMV LISTER was amidships of the TMV COVADONGA, the fore spring of the TMV COVADONGA broke with a loud bang. The linesman, who was in close proximity, was struck on the legs by the broken mooring line and fell into the lock chamber.
At 1915, the pilot on board the TMV COVADONGA informed the Vessel Traffic Services Brunsbüttel Elbe Traffic by radio that a linesman had fallen from the pier onto the fender. At the same time, a lifejacket was seen in the water between the forecastle and the fender. This lifejacket was pulled to the fender by another

linesman who had climbed down. Only then was the floating linesman who was wearing it discovered and pulled onto the fender with the assistance of another linesman. Following that, resuscitative measures were immediately taken.

The immediately alerted emergency doctor and paramedic arrived at 1935 and continued the attempts at resuscitation.
These measures were discontinued at about 2000, by which time the linesman had succumbed to his injuries. The casualty was carried ashore from the lock basin on a stretcher using the TMV COVADONGA's shipboard crane.

3.2 Investigation

The Federal Bureau of Maritime Casualty Investigation (BSU) was informed about the fatal accident early in the morning of 29 October 2008 and immediately began a preliminary investigation.
The main investigation was not started until late November 2009 due to ongoing criminal investigations. Recorded AIS data, radio traffic and witness accounts given by those involved were provided for the investigation.

3.2.1 Wind and swell conditions

The BSU requested an official report on the wind and swell conditions from the Maritime Division of Germany's National Meteorological Service (DWD). The report contains the following summary.

"On 28 October 2008 at 1900 CET, a weak south-west wind with a mean strength of 2 Bft prevailed in the area of the Elbe off Brunsbüttel Lock, gusts were not observed. The sky was overcast but it was dry. It was not until the following hour that light rain set in. The air temperature was 5° C, the water temperature 10° C and horizontal visibility was 4 km. The sun set at 1657 CET and there was a new moon.
In the area of Brunsbüttel Lock, the significant wave height of the wind sea at this time stood at 0.5 m with a period of 2-3 s. In addition, swell with a significant wave height of 1 m and a period of 8 s came from the north-west."

On 28 October 2008, an ebb tide prevailed in Brunsbüttel at the time of the accident. The second high tide was at 1336 and the second low tide should have been at 2041.
Due to the new moon, superposition amplified the tidal forces of the moon and sun. The ebb and flow of these spring tides are particularly strong.

3.2.2 Mooring line ends

According to witnesses, the fore spring on the forecastle was laid from the capstan drum through a roller fairlead and its eye was placed over the white bollard on shore.

The remaining 22.7 m of line was secured by the waterway police on the day of the accident. Its eye was placed over the bollard and the other end broken. The broken end of line found on shore and the broken end on board had relatively straight edges. Information given by the crew indicates that this line had only been in use for two years.
According to the manufacturer's test log of 20 May 2005, the 48 mm thick, 12-strand braided line consists of 40% polyester and 60% polypropylene. During the manufacturing test, the line had an ultimate load of 44 t and a breaking elongation of 15%.

Two days later, on 30 October 2008, the apparently serviceable mooring line was laid out at the scene of the accident by the WSP.

Figure 4: Broken mooring line laid out

Significant deformation in the steel structure of the safety recess cover and sharp edge damages on steel elements, which were the result of earlier accident damage, were discovered during this inspection.
The distance from the broken end of the 22.7 m long laid out line to the sharp edge on the steel structure was measured at 4.8 m by the WSP. Accordingly, the total distance from bollard to damage was 27.5 m. This damage was approximately 13.0 m away from the lowest step of the outer gate (see following drawing). A strand of line fibre was secured; this was on the sharp, rusted edge of the upper profile, which is located just below the upper edge of the lock wall.

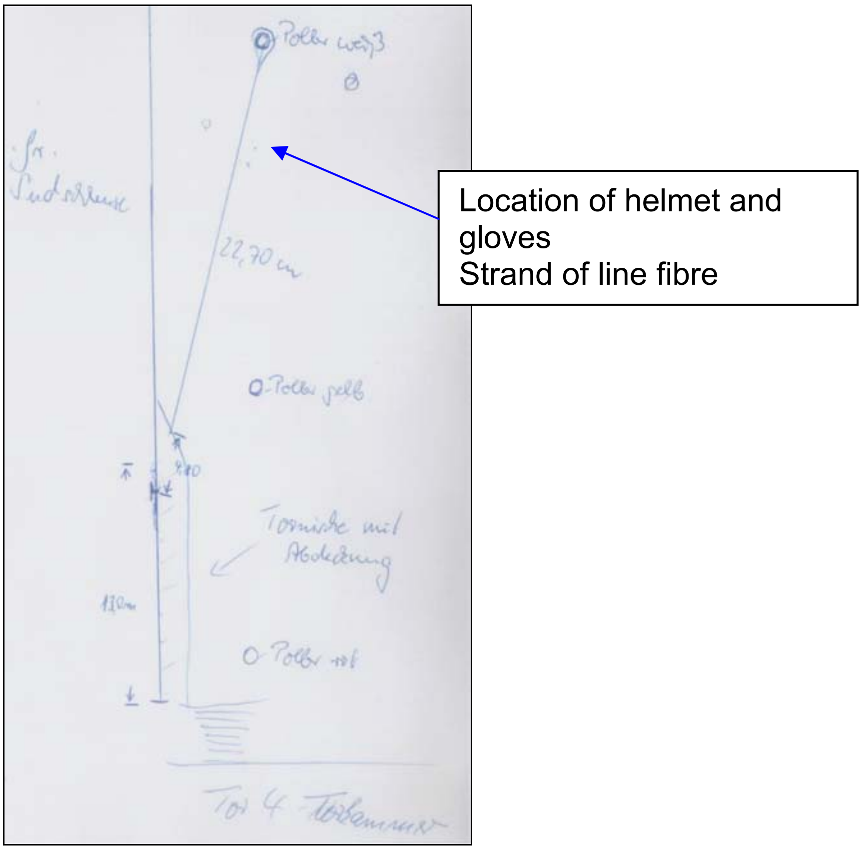


Figure 5: Drawing of the damage by the WSP

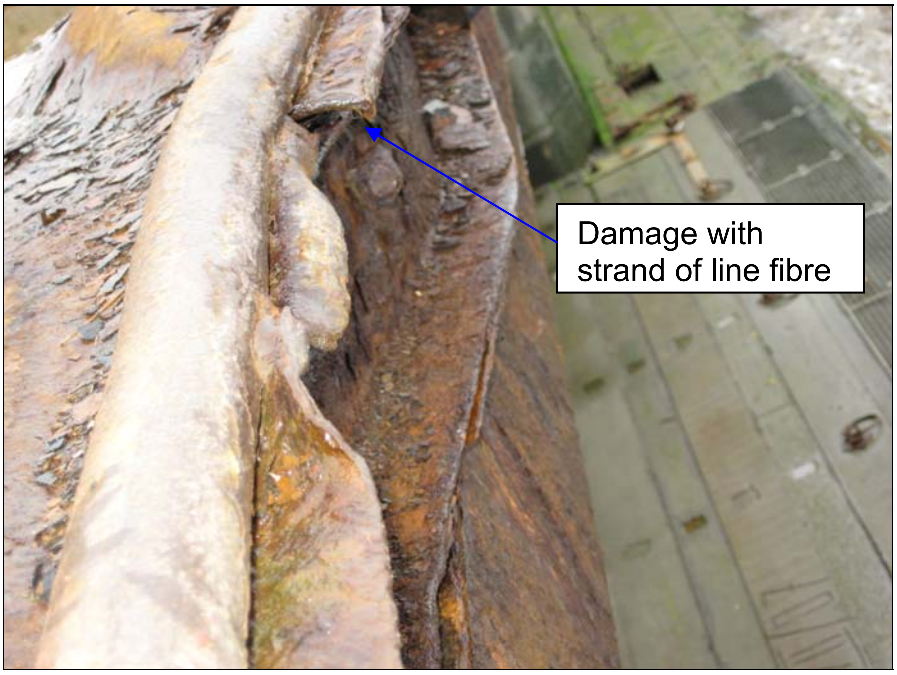


Figure 6: Edge with strand of fibre

Figure 7: Strand of fibre on damaged element

Figure 8: Damage seen from below

3.2.2.1 Investigation of the mooring line failure and the strand of line fibre

To obtain evidence as to whether the discovered fibre strand belonged to the mooring line, the mooring line was cut about 1 m before the position at which it broke and sent to the State Office of Criminal Investigation in Kiel together with the fibre strand for forensic examination.

The examination of the damage to the mooring line revealed that in general the fibre ends had a brush like structure and a few fibre ends were fused together. Furthermore, these fibre ends were partly covered with black or brown deposits. These macroscopic and microscopic examinations of the damage to the mooring line revealed characteristics that indicate a break.

The comparative forensic examination revealed that the strand of line fibre and the mooring line are composed of apparently colourless (white) polypropylene fibres and polyester fibres. The only difference is the deposits of rust on the strand of line fibre, which was found two days later on the rusted, damaged element. While preparing the expertise, it was not possible to clarify whether the deposits of rust had adhered to the strand of line fibre during the two days or were caused by the mooring line first chafing on the rusted area and then breaking. It was also not possible to clarify whether the strand of line fibre originates from the broken mooring line because the material examined is widely used and showed no differentiable colour.

3.2.2.2 Investigation of the break behaviour

During the first visual inspection of the secured mooring line on shore, an eye splice was observed, which was neither spliced according to recognised standards nor manufactured in this manner by tackle companies.

Figure 9: Eye splice

This eye splice on the fore spring had been placed over the white bollard on shore and withstood the load while the line broken some 22.7 m away from the splice.
The secured mooring line was divided into two equal lengths of 7 m for a load test and according to the manufacturer furnished with proper eye splices. Two ultimate load tests were carried out on both lengths of the line using the DYNA-MESS testing machine of Messrs Seil Hering on 9 March 2010.

Figure 10: Ultimate load test

During the first test, the mooring line was clamped on one side with the existing eye splice that was made on board and on the other side with the new eye splice. During this test, the line broken just behind the new splice at a load of 16.78 t. The eye splice made on board, which did not look as robust externally, withstood the load test.
The pulling distance during this test was 1,224.24 mm – 2,035.91 mm = 811.67 mm, which equates to elongation of 11.6%.

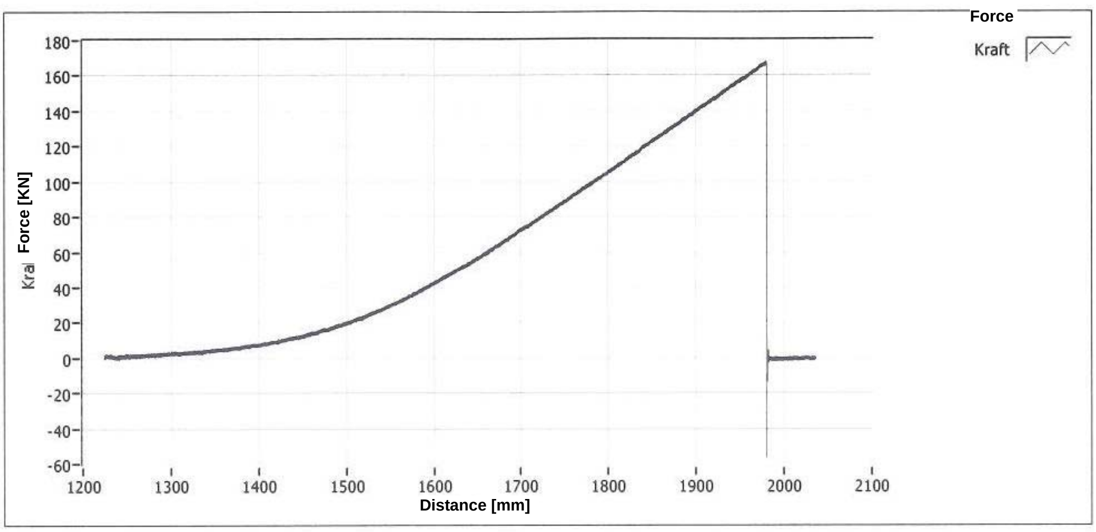


Figure 11: Force/distance diagram, first test

During the second test, the line end also broke, as expected just behind the eye splice, at a load of 21.975 t.
The pulling distance was 1,019.50 mm – 2,074.41 mm = 1,054.91 mm, which equates to elongation of 15%.

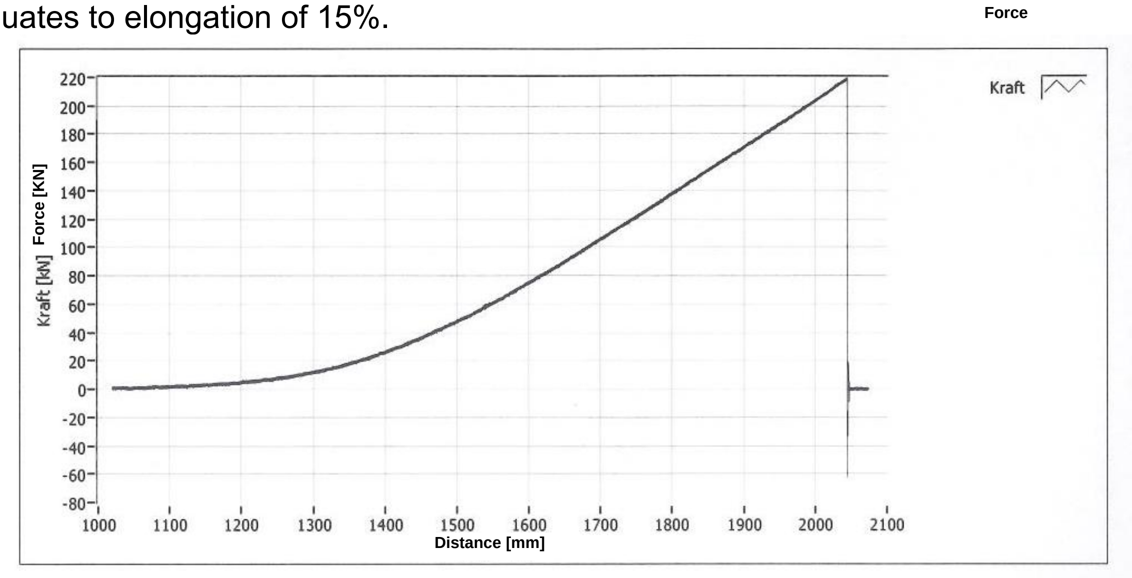


Figure 12: Force/distance diagram, second test

During the tests, the mooring lines broke just behind the newly made splices. The break pattern of each test exhibited the same break structures, but is not identical to the appearance of the break pattern created on the day of the accident.

Figure 13: Break patterns

It was not possible to arrive at further conclusions as to the condition of the line as well as the loads and elongations encountered on the day of the accident during this ultimate load test. The splice made on board withstood the load test and it was not possible to determine the actual elongation and ultimate load by testing with the technical resources available because the remaining line with the eye splice made on board was not long enough for further tests.

3.2.3 Mooring winch

The forecastle of the TMV COVADONGA is equipped with an electro-hydraulic combined windlass and mooring winch. This winch was manufactured in Poland by Rolls-Royce Ullstein FAMA. The specified hauling force with one line end layer on the capstan drum is 8 t and the specified holding force of the band brake is 22 t.
Damage to the capstan drum or band brake was not discovered and no other damage to the winch or on the forecastle was reported.

3.2.4 AIS data

AIS data made available by the Kiel Canal (NOK) Vessel Traffic Services were used to evaluate the speed. These data should be viewed with caution because, as can be seen on the following pictures especially with respect to the vessels in the Große Nordschleuse (large northern lock), wrong positions are often shown due to imprecise entry of the vessel's parameters (antenna position, length and breadth of the vessel, etc.), accuracy of the stored nautical charts, interference and GPS inaccuracies.
The vessel parameters were entered with sufficient accuracy for the TMV COVADONGA and the TMV LISTER and subsequent tendencies caused by vessel motions, which were compared with the raw AIS data, can be identified:

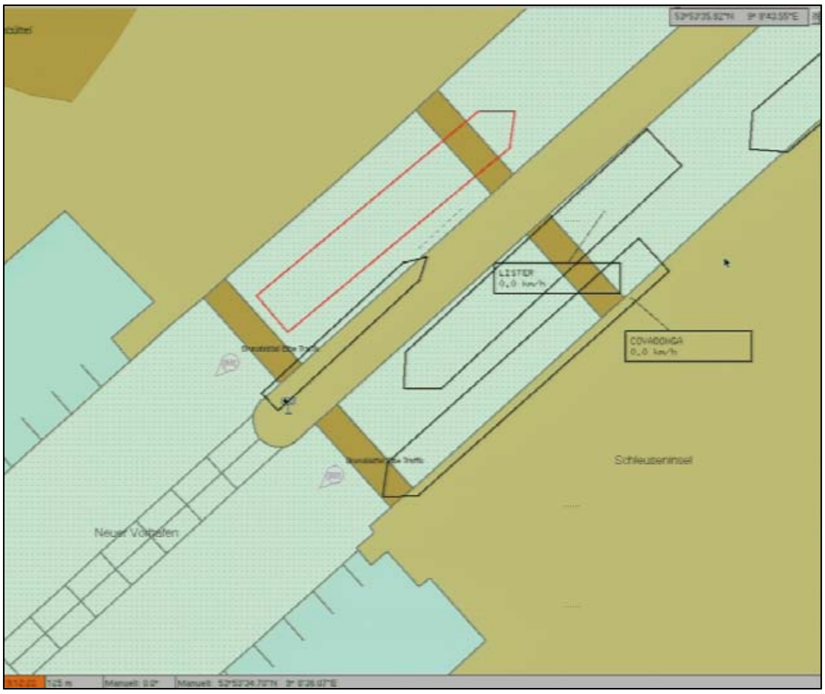


Figure 14: AIS data from 191220

TMV LISTER and TMV COVADONGA are made fast. Speed = 0.0 km/h. The theoretical lateral distance between the moored vessels is approximately 6 m (breadth of lock – (beam of LISTER + beam of COVADONGA + 2 x boom breadth))

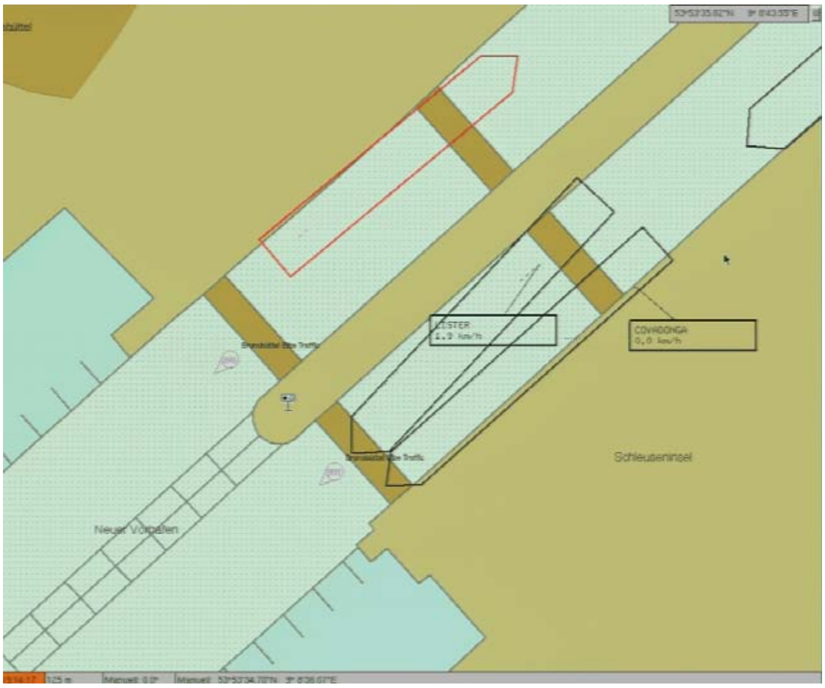


Figure 15: AIS data from 191417

TMV LISTER picked up speed and achieved a manoeuvring speed of 1.9 km/h as she passes stem to stem. The AIS data indicate that the TMV COVADONGA is pulled astern at a non-recorded speed (see position of stem in previous figure).

Figure 16: AIS data from 191455

TMV LISTER proceeds at 3.8 km/h. TMV COVADONGA moves ahead, here already at 0.3 km/h.

Figure 17: AIS data from 191600

TMV LISTER has a speed of 5.5 km/h and TMV COVADONGA a speed of 0.9 km/h.

Figure 18: AIS data from 191620

TMV LISTER continues at 5.4 km/h. TMV COVADONGA has a speed of 0.5 km/h, which drops to 0.0 km/h by 191800. The position of the stem resp. the vessel has moved forward considerably.

3.2.5 Radio recordings

At 190920, the TMV LISTER reports in on VHF Channel 68 (Brunsbüttel Elbe Traffic) and states that as first vessel she will sail out of the new southern lock with a draught of 7.40 m. At 191540, the TMV COVADONGA makes contact on the same channel and reports the accident for the first time: *"We have had an accident here, the spring is broken. A man has fallen from the pier onto the fender. I do not know what is going on."*

Further more detailed radio traffic follows immediately on VHF Channel 13 (Kiel Canal 1) and the emergency services are alerted. At 191938, the following message is sent from on board the TMV COVADONGA: *"As far as I can see, only the lifejacket is floating, the man is nowhere to be seen."* This message is corrected from on board at 192220: *"Yes, the man appears to be in the lifejacket, they have pulled him onto the boom, I was given incorrect information. He must/appears to be injured, there is no movement."*

3.2.6 Witness accounts

All witnesses made statements willingly.

3.2.6.1 Shore-based witnesses

At the time of the accident, one other linesman assigned to the aft ship of the TMV COVADONGA was on shore in addition to the deceased linesman. There was no visual contact between the two linesmen as the approximately 2 m middle gate, which is passed by climbing 13 steps, obstructed the forward and rear view.

Immediately after the TMV LISTER cast off, the TMV COVADONGA made a forward movement while the stern line was still in place. An aft spring was not deployed. The momentum of the forward movement increased and a creaking noise was heard in the stern line. The crew on the aft ship signalled to the linesman to move away and began to slacken the line. While the linesman was moving behind the cover of a construction cabin, he heard a loud bang and assumed that a line had reportedly broke in the area of the forecastle of the vessel.

A short time later, the pilot of the TMV COVADONGA called down to him from the wing and said he should go forward because his colleague had reportedly fallen into the water. The linesman then ran over the middle gate to the front of the vessel and saw a broken line hanging over the white bollard. The hart hat and working gloves were scattered near the bollard, but nobody was to be seen. The linesman looked into the lock basin and saw a lifejacket between the vessel and wooden boom; however, a head and arms or a floating person were not seen. Two colleagues ran to the scene and immediately climbed down the ladder to the boom to pull in the lifejacket. The lifejacket was floating about 3-4 m away from the boom; it was then discovered that it was supporting the missing linesman. The deceased linesman was pulled onto the boom.

The lifejacket was opened and the upper body exposed, after which resuscitative measures were immediately started. This was continued until the emergency doctor arrived with his assistant.

The linesman estimated the forward movement to be some 5 m before the mooring line broke, after which the vessel continued to move further forward.

3.2.6.2 Witnesses on board the TMV COVADONGA

During the manoeuvre in the lock, the second officer, one bosun and an able bodied seaman were working on the forecastle while the third officer and an able bodied seaman were assigned to the stern. Communication among themselves was conducted in Spanish, the master and pilot spoke in English.
The head line was passed through the forward port roller fairlead and the fore spring through the rear port roller fairlead. Only one stern line was in use at the stern. The canal pilot disembarked the vessel after she made fast and the sea pilot boarded at 1850. Due to the low water level, the lines between the vessel and bollards were practically horizontal at the time.
According to statements given, the distance between the TMV LISTER and the TMV COVADONGA was about 4 m. At 1915, the TMV LISTER cast off with the support of the bow thruster. It was clearly evident that the TMV LISTER and TMV COVADONGA were interacting and the TMV COVADONGA appeared to be moving forward. The distance between the two vessels reduced to about 2 m. It was noted that the mooring lines touched the edge of the quay wall and ran in a downward angle to the vessel's fairleads. After the TMV LISTER had passed approximately two thirds of the vessel, a loud noise (*sounded like a gunshot*) was heard on the bridge to the port side and immediately after the master was informed by the second officer that the fore spring had broke. It was noticed from the port bridge wing that a linesman on shore was missing; however, nobody was seen in the water.
The crew members on the forecastle were instructed to slacken the head line and the bow thruster was operated so that the bow would move to starboard in order to increase the distance between the hull and the boom.
Movement ahead due to the suction effect was also noticed on the forecastle. The lines ran down from the bollards on the quay to the vessel because of the decreased water level and touched the edge of the quay wall. No tension/tearing noises were heard until the loud noise.
The emergency services arrived at 1935. The shipboard crane, which was positioned amidships, was used to lift the casualty onto the quay on a stretcher.
At 2005, the pilot was informed of the death of the linesman.

3.2.6.3 Witnesses on board the TMV LISTER

The TMV LISTER initially proceeded at a rate of speed of 2 (dead slow ahead) and then at 3-4 (slow ahead). According to statements given by members of the crew, the distance separating the two vessels reduced to 4 m as the stern of the TMV LISTER was approximately amidships of the COVADONGA. The distance was subsequently increased to 5-6 m by operating the bow thruster. While the stern of the LISTER passed the bow of the COVADONGA, it was observed how the crew members on the forecastle of the COVADONGA quickly separated.

It was also observed how on shore about 2-3 m from the bollard the fore spring broke with a loud noise, struck the linesman on his legs, that the linesman was thrown into the air and fell head first into the water between the vessel and quay.

3.2.7 Local inspection

The witnesses and WSP investigators were interviewed about the accident during a local inspection on 30 March 2010. Particular attention was given to the discovery of the person in the water. Only a lifejacket was seen floating about 1-1.5 m away in the water. It was only evident that the lifejacket was supporting a person, whose head lay sideways below the water, when this lifejacket was pulled to the pier. The lifejacket was not fitted with a recovery strap or crotch strap and was closed at the chest but had obviously ridden up. For the most part, the damage to the lock wall had already been repaired or removed by the time of this local inspection. It was no longer possible for the BSU to accurately measure the distance from the bollard to the damage in question on the edge of the lock.
During a further inspection on 11 June 2010, the entire area around the safety recess cover had been completely renewed.

Figure 19: Damage in March 2010

Figure 20: Repaired section in June 2010

3.2.8 Lifejacket and cause of death

3.2.8.1 Lifejacket

The deceased linesman was wearing an orange SECUMAR BS 16 lifejacket. The lifejacket was inflated when it was discovered in the water without it being evident at the first moment that the lifejacket was still supporting the casualty, whose head was below water. The lifejacket was tested on behalf of the WSP by Messrs Consalt in Kiel. The test revealed:

> *"Poor condition but serviceable;*
> *lifejacket inflated, water activated;*
> *made in February 1999;*
> *last service was 08/08 – inspection stamp no longer legible in order to identify the examiner;*
> *automatic inflator works perfectly."*

3.2.8.2 Cause of death

It would have been helpful to the BSU's investigation if the cause of death had been established. However, following requests by the WSP an autopsy of the body was refused on several occasions by the public prosecutor's office in Itzehoe. A reason for this refusal was not apparent from the file.

The right work shoe (Class S 3) of the deceased, which was torn diagonally across the instep to the sole, was found in the water.

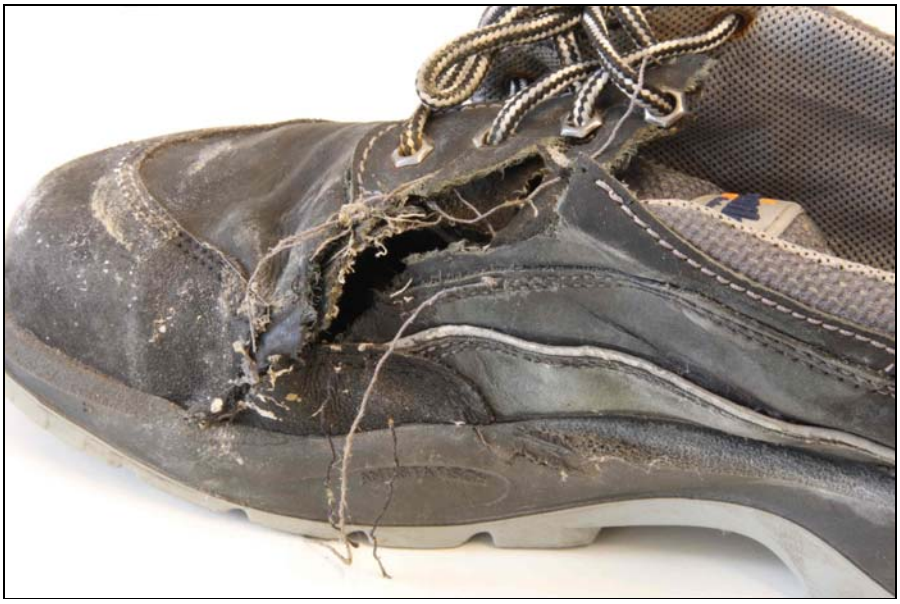


Figure 21: Shoe of the deceased

He was still wearing the left shoe, which was undamaged. Based on this and the photos with identifiable injuries that the BSU have on hand, which show an open fracture on the right lower leg with detached skin to the foot, it can be assumed that the deceased was struck by the brokenmooring line on the right leg and foot.
According to statements given, the linesman was bleeding from the nose and ears during the resuscitation attempt. Photos also show severe injuries on the right side of the face and bleeding from the mouth, nose and ears.

It remains unclear whether the linesman fell into the water immediately or first onto the wooden boom and then into the water. Therefore, it is not possible to clarify conclusively whether the death was caused by drowning or the described injuries.

The BSU requested a forensic opinion for the investigation of the accident from the Hamburg Port Health Centre (Head: Dr Schlaich), Central Institute of Occupational Medicine and Maritime Medicine (ZfAM), in coordination with Professor Püschel, Forensic Medicine at UKE Hamburg, on the basis of the photos on hand and the report on the investigation of the death by the police. It was noted that it was only possible to establish the pattern of injury ostensibly and that determination of the cause of death could only be made by a forensic pathologist through a post-mortem examination, possibly followed by a dissection. Excerpt from the opinion:

"It is not clear whether the man fell straight into the water or whether he first struck an object. In addition to the very severe injury to the lower leg, it is not possible to define other injuries in the photos with certainty.
However, it looks as if there are also head and neck injuries. (…) Much speaks for the possibility that further injuries occurred in the area of the chest, throat, and nasopharynx. Otherwise, it would not be possible to explain why there was so much bleeding from the mouth and nose. At any event, the man would have probably lost a considerable amount of blood solely due to the severe injuries to the right lower leg, which would have required decisive intervention in the shortest possible time. The right leg would have urgently required dressing with a tourniquet as quickly as possible. (...)
Under the given circumstances (extended period in the water, extended period until the arrival of the emergency services), drowning is an added possibility and the blood loss from the right leg would have probably been fatal (also without other injuries).
In my opinion, drowning and severe blood loss from the injured lower leg would have been avoidable if the man was pulled out of the water immediately and his leg was dressed.
With the aid of additional photographic material, it can be deduced that it is highly probable that the deceased struck the floating fender before finally falling into the water. Moreover, this is consistent with the injury pattern. In spite of wearing a lifejacket, the deceased was found with his face down. Therefore, drowning preceded by unconsciousness due to falling on the floating fender and/or blood loss is possible.
For the purposes of a differential diagnosis, the following causes of death must be considered:

- *Death due to drowning preceded by unconscious caused by falling on the floating fender and/or blood loss*
- *Death due to blood loss*
- *Death due to falling on the floating fender*

That the deceased was found floating face down requires particular attention. In that respect, the lifejacket was apparently not fit to prevent drowning when one loses consciousness."

3.2.9 Investigation in the lock and on board

3.2.9.1 Height of the edge of the lock on the day of the accident

The Elbe water gauge at Mole 4 relative to tide gauge zero at 1915 on 28 October 2008 had a value of 4.22 m. Tide gauge zero is 5.00 m below mean sea level (MSL). Based on MSL, that results in a water level of -0.78 m below MSL.
According to information from the competent Waterways and Shipping Authority (Cuxhaven), the Elbe water gauges are routinely compared with each other. Based on these comparisons, it follows that a height error in the system accuracy at the time of the accident could be +1 cm to +5 cm too high at low tide. This means that the actual water level at the gauge at Mole 4 was in the region of 4.21 m to 4.17 m or -0.79 m to -0.83 m based on MSL.

According to the drawing, the upper edge of the lock wall is +4.50 m above MSL. Therefore, at the water level on 28 October 2008 the distance from the surface of the water to the upper edge of the lock wall was 4.50 m + 0.79 m (resp. + 0.83 m) = 5.29 m (resp. 5.33 m).

Control measurements during a local inspection on 30 March 2010 using a 30 m steel tape measure as well as a laser measuring device (Leica Disto) were carried out on the dimensions of the lock wall and compared with the data from the gauge.

It can be concluded that the height from the surface of the water to the upper edge of the lock was between the 5.29 m and 5.33 m on the day of the accident.

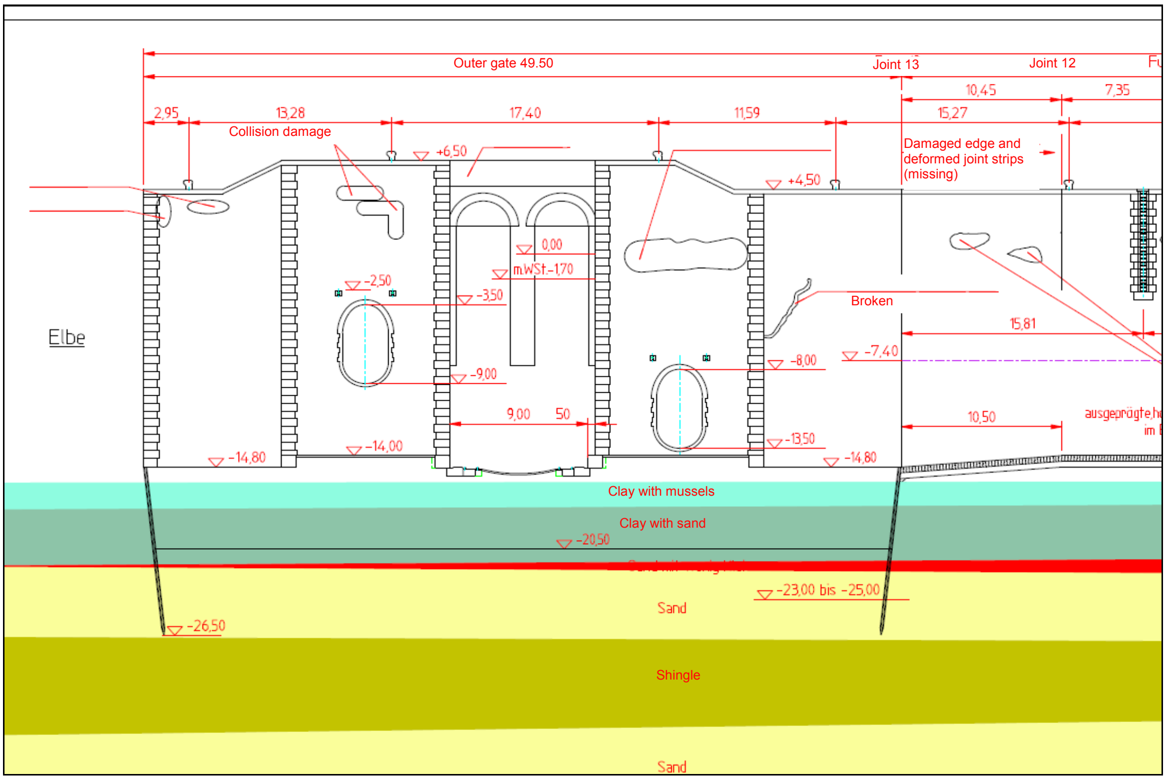


Figure 22: Longitudinal profile of the lock

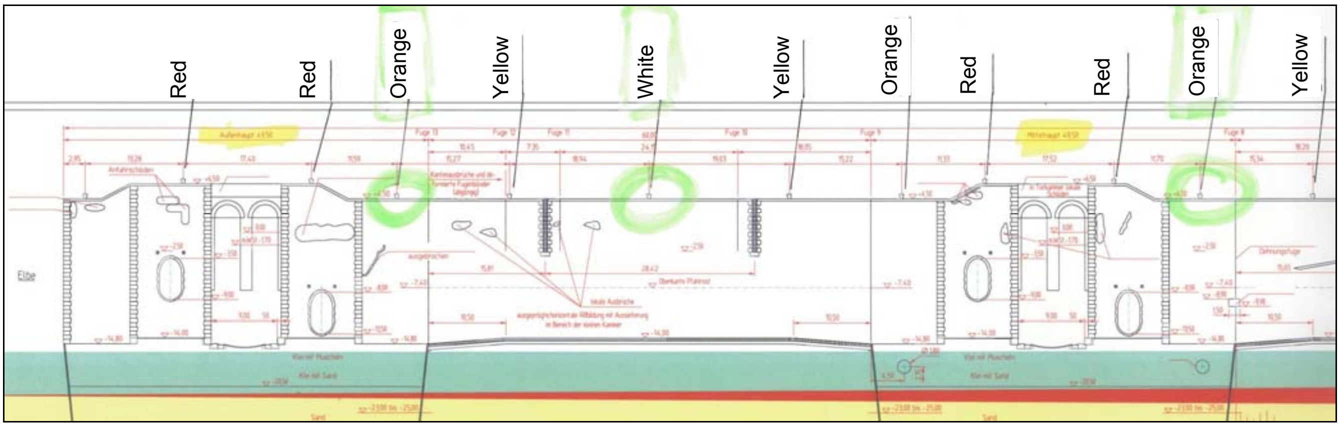


Figure 23: Bollard spacing and colour coding

It was not possible for the linesmen to see one another while carrying out their task due to the raised middle gate.

Figure 24: View from the outer wall with bollards, middle gate and safety recess

3.2.9.2 Distance from the fairleads on the forecastle to the surface of the water

The COVADONGA has two fairleads on the port bulwark and two on the starboard bulwark; these are used for the fore spring and head line. Warping rollers are positioned on the stem on the port and starboard sides for the head lines. The following Mooring Arrangement Plan has been approved by the classification society:

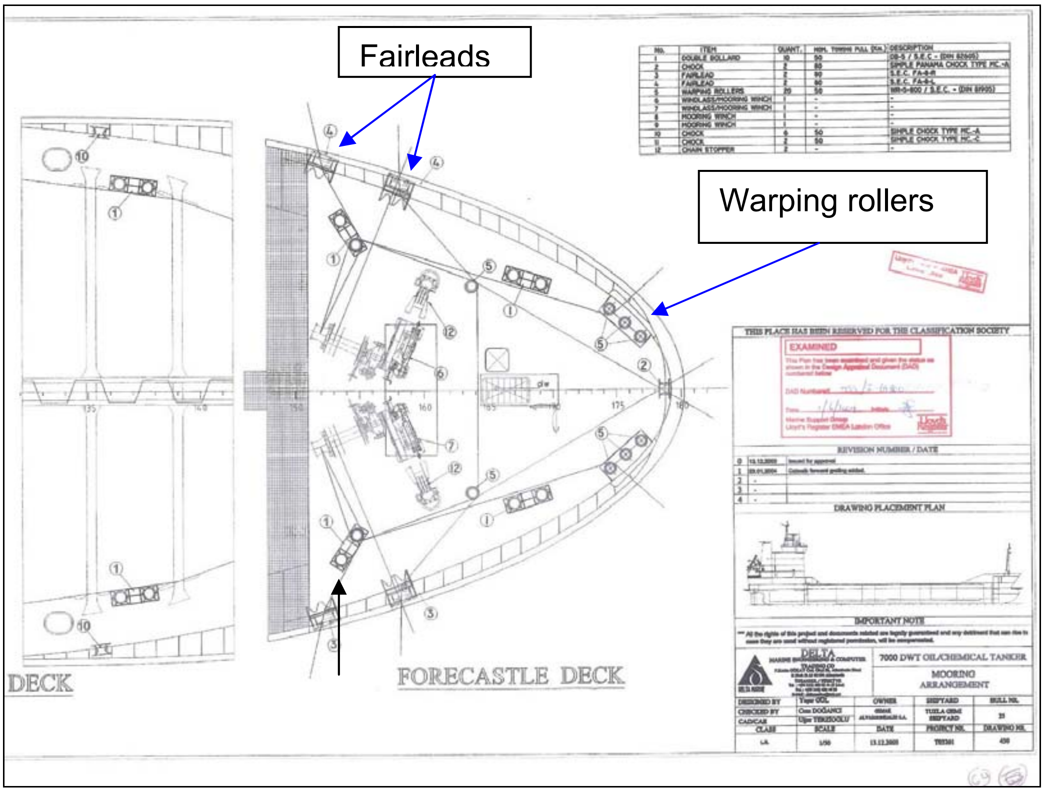


Figure 25: Mooring plan, forecastle

The WSP measured the fairleads on the forecastle on board the TMV COVADONGA in Brunsbüttel Lock on 7 December 2008. TMV COVADONGA was in ballast and a draught of 3.60 m fore, 4.20 m amidships and 5.00 m aft was established. The distance from the fairleads on the forecastle to the water line was measured at 8.30 m at the rear fairlead and 8.10 m at the forward fairlead.

Accordingly, the distance from the rear fairlead to the bottom edge of the Kiel (BEK) is 11.90 m (3.60 m + 8.30 m). That corresponds to the value measured by the classification society, Lloyd's Register, according to the General Arrangement Plan (GA Plan).
The rear fairleads are 7.40 m from the forward perpendicular and positioned 11.90 m above the BEK in the GA Plan.

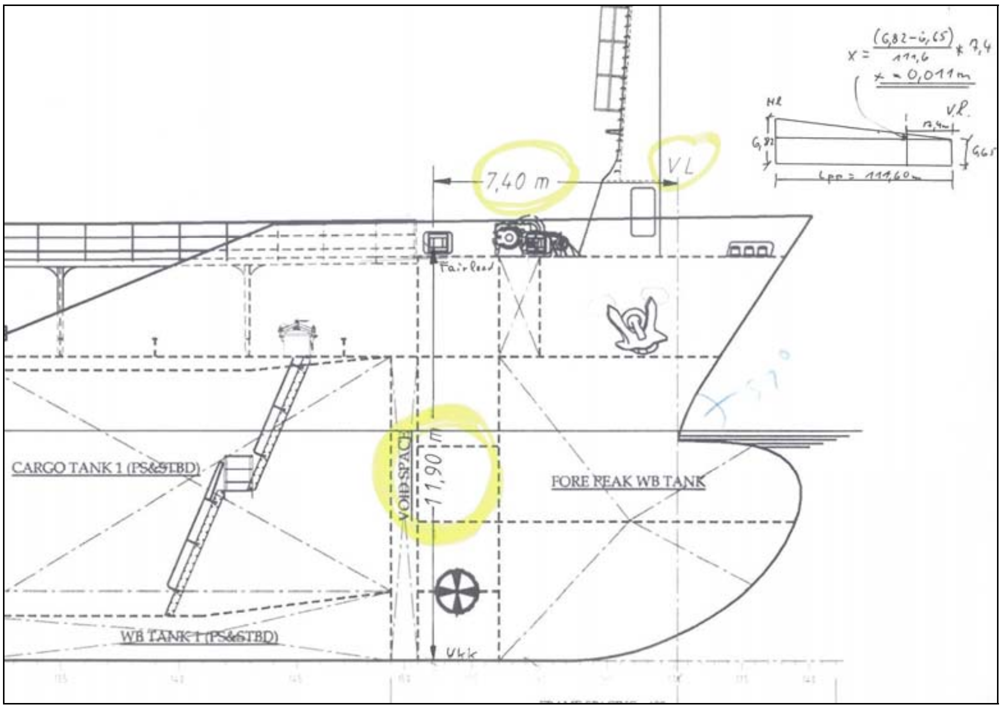


Figure 26: GA Plan, forecastle

During a survey on board by the BSU on 11 June 2010 in Brunsbüttel, these values determined by the WSP and the values in the GA Plan were confirmed with the current draught. The rollers in the fairleads ran smoothly and no sharp edges were observed.

Statements vary with respect to the draught on the day of the accident. In the written statements of the crew of 7 December 2008, an even draught of 6.82 m was recorded *("This resulted in a draught of 6.82 m even keel").* The initial accident report by the WSP indicated a draught of 6.74 m fore and the Vessel Traffic Service stated that the draught was 6.90 m.

In the forms of the Federal Bureau, which were submitted in February 2010 by the counsel for the vessel operator, the draught is stated as being 6.65 m fore, 6.74 m amidships and 6.82 m aft. These values seem to be more realistic and are confirmed by photos taken in the roadstead off Brunsbüttel on the day of the accident:

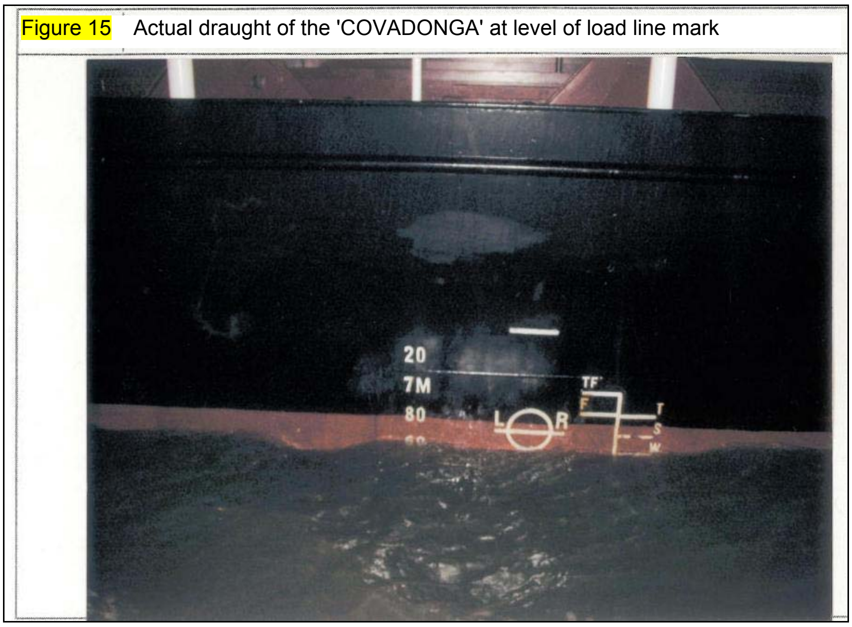


Figure 27: Load line mark at Brunsbüttel roadstead on 28 October 2008

Based on the different information, the height above the surface of the water of the rear fairlead on the forecastle is:

1. At an even draught of 6.82 m = 11.90 m - 6.82 m = 5.08 m

2. At an even draught of 6.74 m = 11.90 m - 6.74 m = 5.16 m

3. At 6.82 m aft, 6.74 m amidships and 6.65 m fore =
   a) Without regard to the fact that the load line is not identical with the distance of the fairlead of 7.4 m from the forward perpendicular = 11.90 m - 6.65 m = 5.25 m
   b) Fairlead is 7.4 m behind load line mark = 11.90 m - (6.65 m + 0.01 m) = 5.24 m

3.2.9.3 Line guidance on the forecastle

The COVADONGA has two diagonally positioned combined windlass/mooring winches on the forecastle. Each winch has a chain grab for the anchor chain on one side and a capstan drum and warping head on the other. The capstan drum is divided by a centre plate into a storage section and working section. Basically, only one layer of rope must be put on the working drum when making fast. Precise knowledge of the mooring place, especially the existing bollards on the quay over which the lines will be put, is needed to determine the necessary line length when preparing to berth.

The statements given by the crew with respect to the way in which the lines were guided on the forecastle on the day of the accident are consistent. These indicate that the head line ran through the forward fairlead and the fore spring through the rear fairlead *("The fore spring went through the port aft fairlead; the head line went through the forward port fairlead).* This statement does not conform to standards or the routine practised on board. According to photos on the Internet and also during the survey by the BSU on 11 June 2010, the fore spring is guided through the forward fairlead and the head line runs from the winch opposite the mooring side through the warping rollers at the stem.

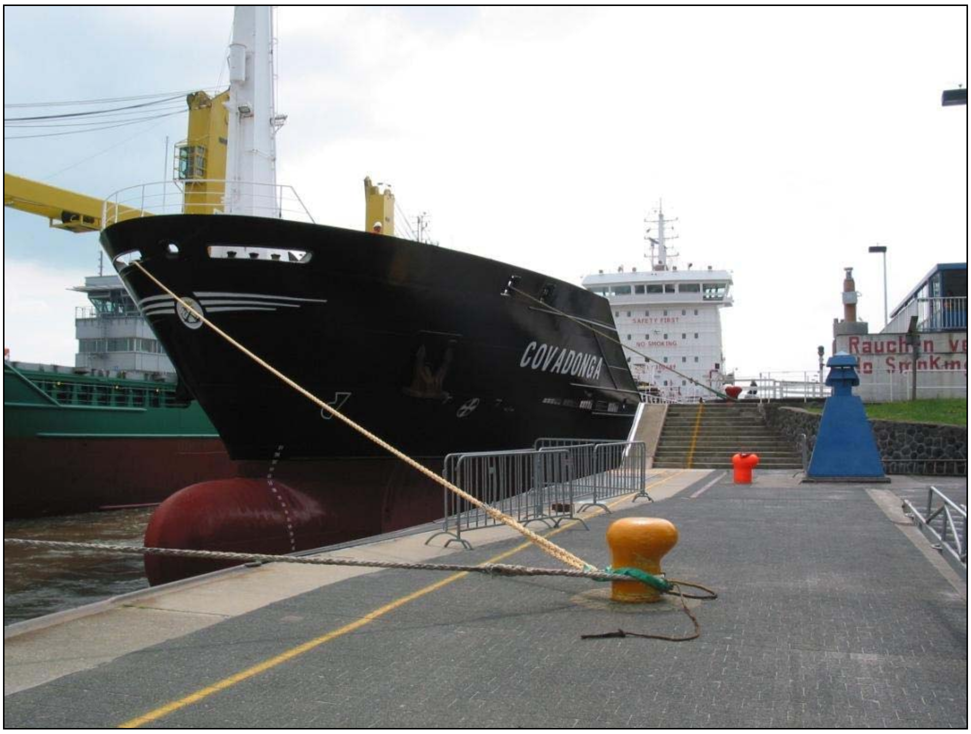


Figure 28: Head line and fore spring on 11 June 2010

As regards line guidance on the forecastle, according to the above photograph the head line ran from the working section of the starboard winch over warping rollers on the deck and through the forward starboard warping rollers and the fore spring ran directly from the working section through the forward port fairlead.

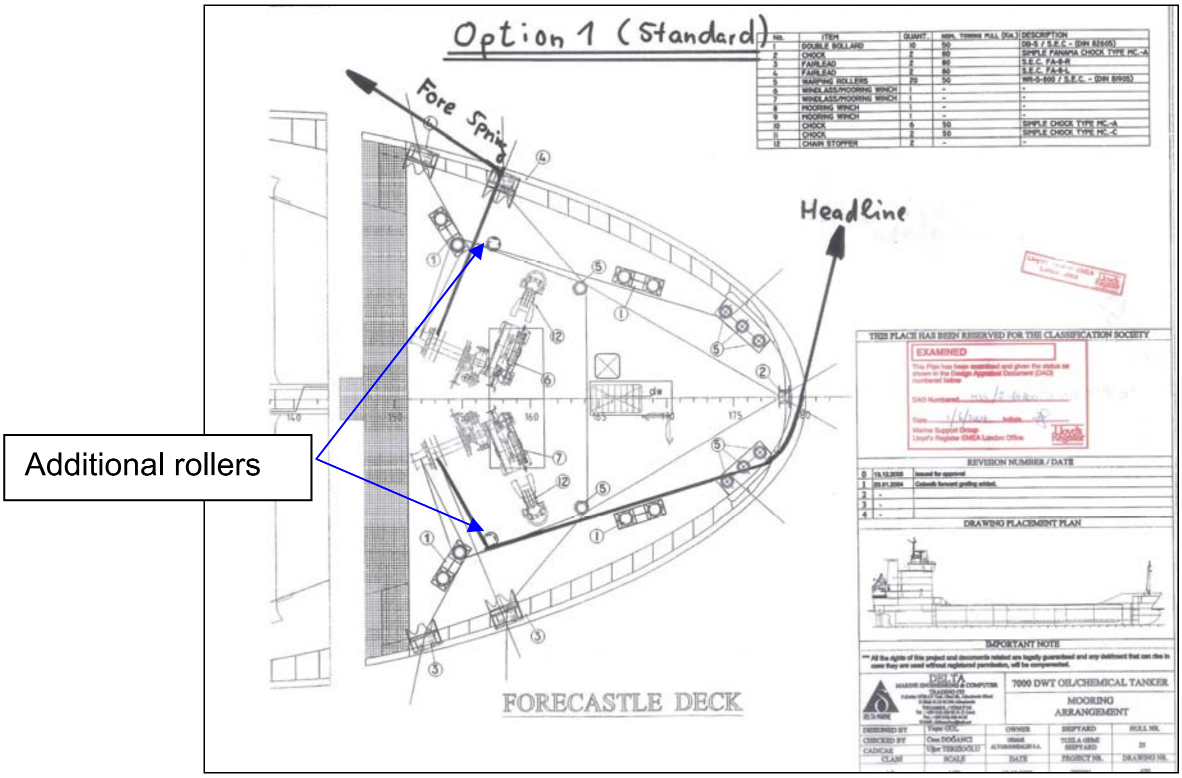


Figure 29: Standard line guidance

It was confirmed in a letter from the vessel operator's legal counsel dated 7 September 2010 that the line guidance shown above in Fig. 29 was that used on the day of the accident. It is noted in the letter that in their first statements the crew members are referring to the guidance of the fore spring on the fairlead, which is located in extension of the relevant winch. The aft fairlead was not used and also not mentioned in the statements. The account of the written testimony of 28 October 2008 *("The fore spring went through the aft port fairlead, the head line went through the forward port fairlead)* in the BSU report regarding the used fairleads is misleading. The witnesses did not indicate that of the two port fairleads it was reportedly the rear one which was used for the fore spring. The witnesses indicated that the fairlead used is located in the aft ship of the bulwark on the port side with their statement: *"the fore spring went through the aft port fairlead."*[3]

During the survey by the BSU, it was found that the Mooring Arrangement Plan approved by LR is not consistent with the actual circumstances. Another warping roller on a base has been additionally installed on board on the port and starboard side.

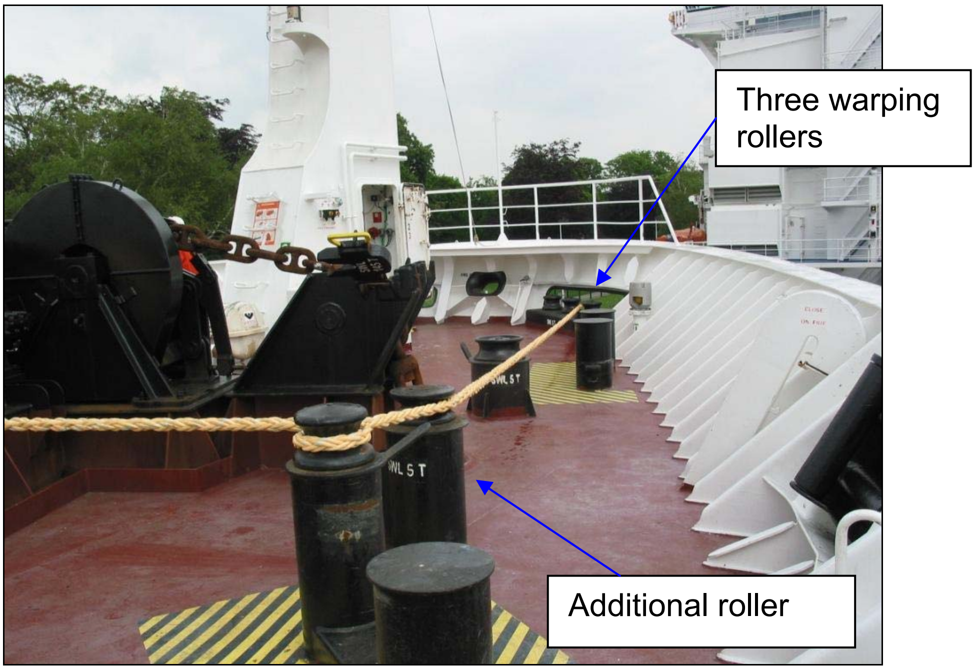


Figure 30: Line guidance of the head line on 11 June 2010

[3] Note: According to shipboard surveys and the Mooring Arrangement Plan (Fig. 25), on the forecastle bulwark there is only one aft fairlead and one forward fairlead on the port and starboard side respectively. A Panama fairlead is positioned midships on the stem and next to that 3 warping rollers are positioned on a base on the port side and 3 on a base on the starboard side.

Figure 31: Line guidance of the fore spring on 11 June 2010

Following the first written statements of the crew on 28 October 2008 about the line guidance on the day of the accident, according to which the head line ran through the forward port fairlead and the fore spring through the rear port fairlead, the forms of line guidance shown below would have been possible:

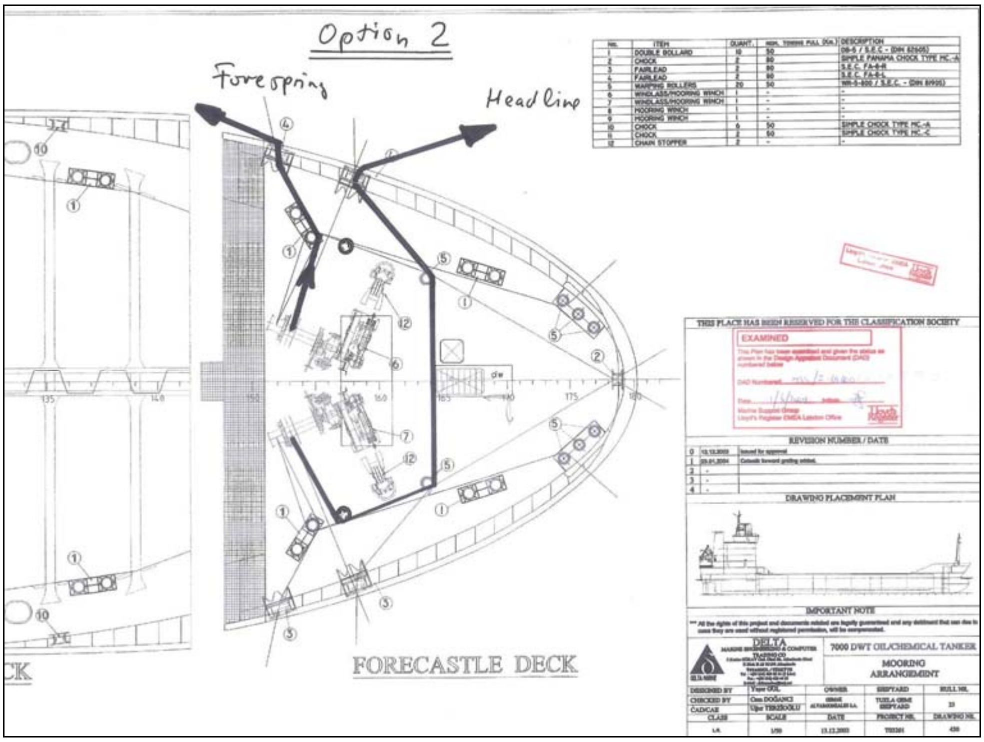


Figure 32: Line guidance option 2

In the case of the second option, the head line would be deflected twice; this would inevitably lead to friction losses and is not ideal in terms of safety. Moreover, a life raft is positioned midships on the aft edge of the companionway/foremast, which can chafe the mooring line.

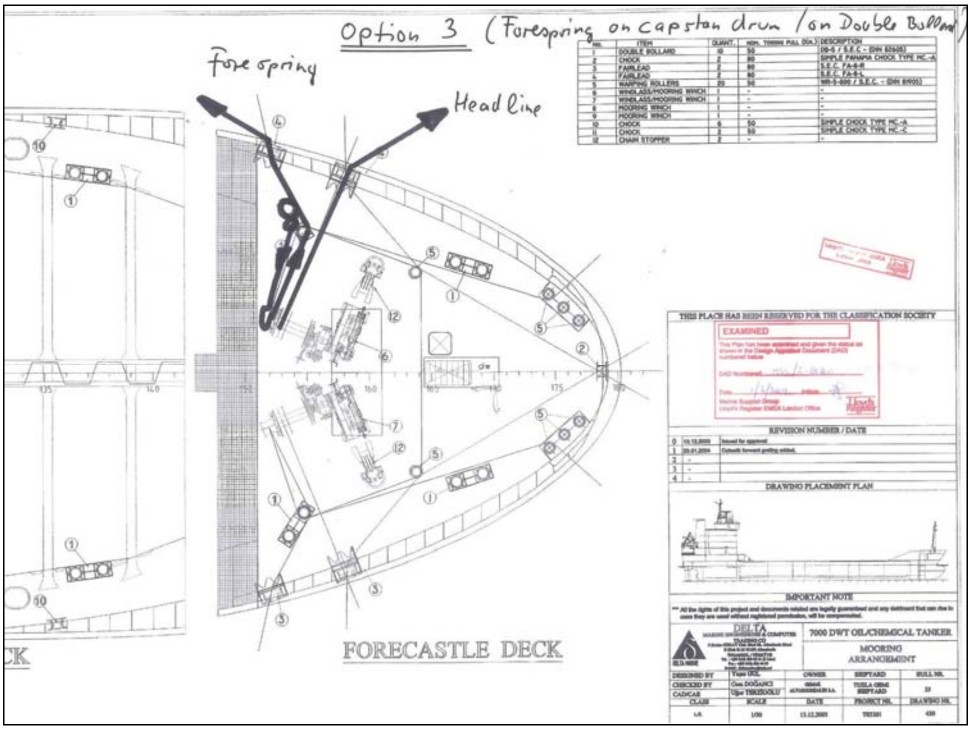


Figure 33: Line guidance option 3

In the case of the third line guidance option, an additional line, which is not used on the capstan drum, would have been necessary for the fore spring. This line is passed over the warping head and placed on the twin bollard. Automatic slackening of the line under load is then not possible. The possibility of a third line being used for the fore spring is opposed by the fact that the police report does not contain any corresponding remarks and the photos of the line wind up on the capstan drum taken on board on the day of the accident show the same blue coloured strands.

3.2.9.4 Position of the vessel in relation to the bollards

The COVADONGA has two Panama fairleads on each side of the aft deck. During the survey on 11 June 2010, the stern line was passed over a warping roller through the rear Panama fairlead. These Panama fairleads are level with the warping rollers and used for guiding the aft spring or stern line.

Figure 34: Stern fairleads

Figure 35: Line guidance on the stern

Based on the statements and AIS recordings, the position of the vessel in relation to the bollards is shown below. In this position, the vessel is made fast with two short breast lines and a spring.

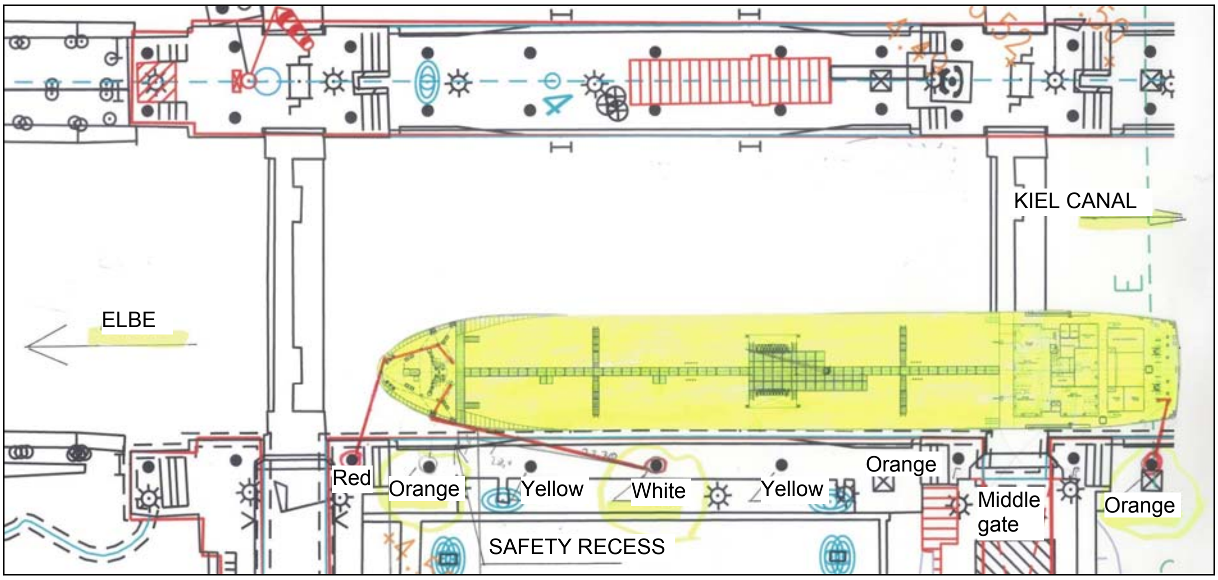


Figure 36: Mooring position on the day of the accident

According to the above drawing, the line guidance of the head line led it through the starboard warping rollers at the stem and is consistent with common practise on board. There are no clear statements as to arrangement of the head line on shore. In all likelihood, it was placed on the red bollard on the outer gate. With the vessel in this position, the head line is deployed as a short breast line.

The remainder of the broken fore spring was found on the white bollard. According to the latest statements by the crew, the fore spring was passed through the forward port fairlead.

Corresponding statements indicate that on the day of the accident the stern mooring line was deployed as a short breast line and placed around the orange bollard on shore in front of the middle gate.

4 ANALYSIS

4.1 Other instances of lines breaking

Incidents involving broken mooring lines in locks are not at all uncommon and have various causes. In general, lines break when vessels are still moving ahead, for example, due to poor communication with the linesmen on shore, incorrect assessment of the nautical situation or a technical failure on the vessel or lines.
However, increased instances of the lines of moored vessels breaking when other vessels are departing, in particular, towards the Elbe, have become apparent and statistically recorded only recently.
In 2009, a total of 12 broken lines were reported in Brunsbüttel Lock. These consisted of 10 accidents in which the fore spring broken during entry and two cases involving broken head lines on moored vessels while other vessels were departing; however, there were no injuries. One other incident involving a broken head line occurred on 1 April 2010. A tanker moored behind the first vessel to depart was affected by the backwash and a linesman on shore was struck on the thigh and slightly injured. Hence, including the accident concerning the TMV COVADONGA, there are four cases of broken lines involving moored vessels and vessels heading from the canal for the Elbe and manned by Elbe pilots.

4.2 Passage of the line from the lock wall to the vessel

The distance from the surface of the water to the upper edge of the lock was between 5.29 m and 5.33 m on the day of the accident; the distance to the rear fairlead on the forecastle was between 5.08 m and 5.25 m based on the different information given as regards the draught. Therefore, with a taut mooring line this fairlead was lower than the upper edge of the lock wall at any event. Depending on the aft trim, the distance between the forward fairlead and the surface of the water is approx. 5-6 cm greater than the distance of the rear fairlead. When the dynamic element of a draught reduction caused by the suction and waves of the departing TMV LISTER and the elongation and loosening of the fore spring is added to this static appraisal, it can be assumed that with respect to the height differences behind the existing damage, the mooring line could catch on the lock wall.

The following drawing from 'Mooring and Anchoring Ships Vol. 1[4]' illustrates the danger of lines breaking when vessels are moored below the upper edge of the lock wall.

[4] The Nautical Institute 2009, ISBN No. 978 1 906915 934

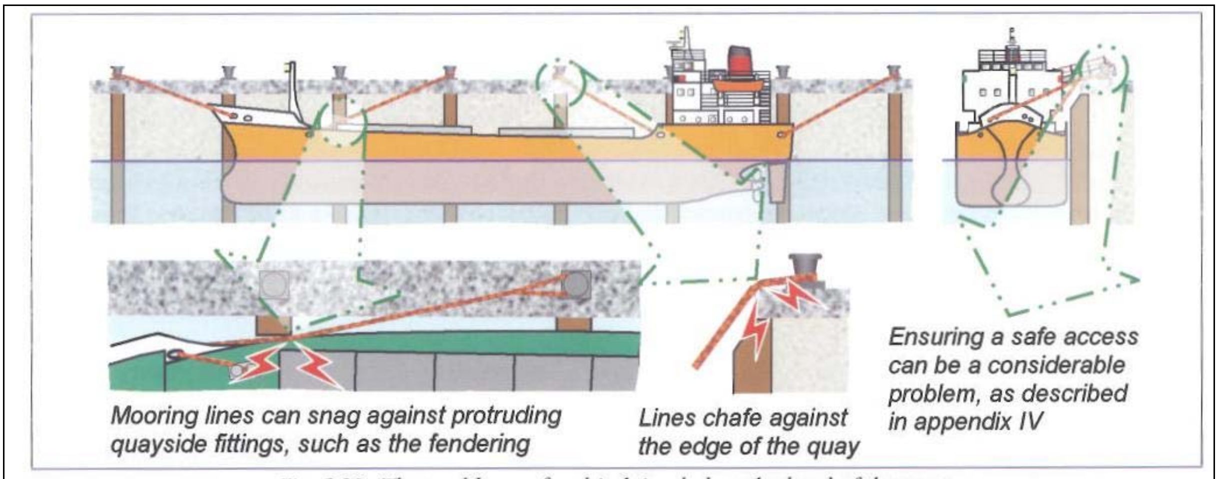


Fig. 5.33 The problems of a ship lying below the level of the quay

Figure 37: Danger of lines breaking with low lying vessels

According to the above drawing, there is a risk that the lines of a vessel can snag on vertical piles or fenders. This potential risk is low in the lock as vessels moor at a sufficient distance due to the floating wooden boom, which is at least 1.40 m wide. Only if the stern of the COVADONGA swayed substantially outward there would have been a possibility that the line would be trapped between the bulwark and upper edge of the lock. There are no statements regarding this premise.
The second possible risk occurs when the line runs downward over a sharp upper edge of the quay. To prevent this, half-round profiles are welded to the lock edges.
On the day of the accident, the COVADONGA was lower and the welded profile was damaged in the relevant area. Hence, there is a possibility that the line broke on the damaged lock edge.

The length of the line from bollard to the breaking point was 22.70 m, the distance from bollard to the damage on the safety recess cover was 27.50 m according to the measurements of the WSP. To reach the existing damage, the line end would have needed to elongate by 21%. According to the line document of the manufacturer, the minimum elongation is 15% and higher elongation values are not excluded. Ultimate load tests carried out by the BSU revealed elongation of 11.5% in the first test and 15% in the second test. During both tests, the mooring lines broken just behind resp. in the area affected by the new eye splices made especially for the test. It was not possible to determine the actual ultimate load and maximum elongation in the part of the line not affected by the splices. Furthermore, after shipment the mooring lines were pre-elongated by months of use on board and yet elongation of 15% as stated in the manufacturer's certificate was still achieved. The force/distance ratio (elongation) resulting from the ultimate load tests (see Figs. 11 and 12) runs linearly up to the break in the right area of increase. If the ratio of the force/elongation determined in the tests to the required elongation of the discovered fore spring of 21% up to the damage on the lock wall is applied, the following values are returned:

1st ultimate load test: (force 16.76 t / elongation 11.6%) x 21% = 30.38 t
2st ultimate load test: (force 21.97 t / elongation 15.0%) x 21% = 30.76 t

A force of about 30.38 t would have been required to elongate the line to 21% in order for the line to break in the area not affected by the splices. In that case, the specified ultimate load of 44 t resulting from the manufacturer's test would still not have been reached.
According to 'The Nautical Institute, Mooring and Anchoring Ships Vol. 1', elongation values of more than 40% can certainly be expected with new lines and used lines should still achieve 30%.
Based on the above assumptions, with elongation of 21% it is quite possible that the fore spring reached the damaged part of the edge of the lock and chafed until it broke.

The strand of fibre found on the damaged safety recess cover has the same composition as the discovered fore spring; the only difference is that rust deposits were adhered to the strand of fibre.
It was noted that coarse rust was firmly adhered to the entire area of the safety recess cover, which would not easily transfer to a fibre strand resting loosely on its surface. However, any mechanical action would cause this rust to rub off and quickly transfer to the fibre strand due to humidity.
Nevertheless, since the indicated composition of the line is common, the strand of fibre may have come from another vessel, but this would have required the line from the other vessel to chafe in the damaged area two days before or after the accident, causing the fibre strand to adhere to it. There were no reports of this happening.
The break pattern of the fore spring is different to that of the ultimate load tests and has the visual appearance of a cut.
Based on the given conditions, it is likely that the fore spring of the COVADONGA chafed on the damaged part of the safety recess cover and was cut through as if by a blade.

4.3 Mooring

On the day of the accident, the COVADONGA was moored in the lock without an aft spring. The head line and stern line were deployed as extremely short breast lines.

Operating rules apply for the Brunsbüttel locks; however, these do not include a provision for the mooring of vessels.
Experience and practise over the years have led to vessels of the size of the COVADONGA normally being made fast in the lock with a head line, fore spring and a short aft breast line without the use of an aft spring.
Mooring in locks is not described in the relevant regulations and literature.

If one refers to the regulations governing mooring vessels in port, which should be used analogously for short-term mooring in locks, as basic rules according to established seamanship[5], for example, the following applies:

"The safe mooring of seagoing vessels depends on the arrangement of the berths, the size of the vessel, the line material used, passing traffic and the prevailing hydrometeorological conditions. Standardisation as regards the number of lines for making fast is not possible due to the discussed conditions (...) the following may apply as basic rules:

1. *Breast lines should be set in heavy, offshore winds.*
2. *In the event of suction caused by passing vessels, a double fore and aft spring should be set.*
3. *Mooring lines should be kept taut at all times during loading and unloading operations and changing water levels.*

The above rules indicate that breast lines should be deployed in addition to other lines when there is a risk of the vessel swaying outward due to heavy offshore winds. Breast lines cannot replace the necessary stern or head lines. In the case of suction caused by passing vessels, the normally deployed fore spring and aft spring should be doubled. The lines must not slacken and there should be no movement in the moored vessel. If there is slackness in the mooring lines or movement in the vessel because springs are not used, energy peaks caused by wind, swell or current may be generated, which cause the mooring lines to break.

According to these basic rules of seamanship, regardless of size vessels should be made fast in ports or berths at least 1:1, i.e. a head line, fore spring, stern line and aft spring.

Unlike making fast at the end of a voyage, making fast in a lock is simply a stopover in which, in particular, the bridge, engine room and manoeuvre stations are still manned. Moreover, suction caused by vessels passing is different in a lock to that of a port berthing. The lock chamber is a limited area and with regard to the hydrostatic and hydrodynamic forces cannot be compared to a normal berthing. In that respect, in spite of the existing interaction with other vessels in the lock, the deployment of double fore and aft springs can probably be dispensed with under the given conditions. The BSU does not share the opinion of the Lotsenbrüderschaft NOK I (Brotherhood [sic] of NOK I Pilots) that vessels may be made fast without an aft spring and stern line and only with a deployed aft breast line. Rather, according to the aforementioned rules of seamanship, at least those vessels which are not proceeding from the lock first should, at minimum, also be made fast 1:1 if there are several vessels in the lock.

[5] From Seemannschaft 3, Schiff und Manöver (Seamanship 3, Ship and Manoeuvre), VEB Verlag für Verkehrswesen

4.4 Danger areas when lines break

Being in the area of lines, which are under great tension, is not without problems. In general, such hazardous areas are known on board and in the ideal case also marked by a colour.
In the Brunsbüttel and Kiel locks, only the area by the water's edge is marked by a continuous yellow line, from which lifejackets should be worn. Hazardous areas around mooring bollards in which there is a risk of lines breaking are not marked. Marking the area of danger around bollards appears to be difficult because it differs according to vessel type, direction of travel, line guidance, length of deployed line, etc. Therefore, the Waterways and Shipping Administration has classified the entire area of the lock as hazardous and people are not permitted to enter without a specific reason; furthermore, the awareness of lock staff has been raised through training on the recognition of hazards.
The following drawing from 'Mooring and Anchoring Ships Vol. 1' illustrates what happens when a line breaks at the fairlead and snaps back on board:

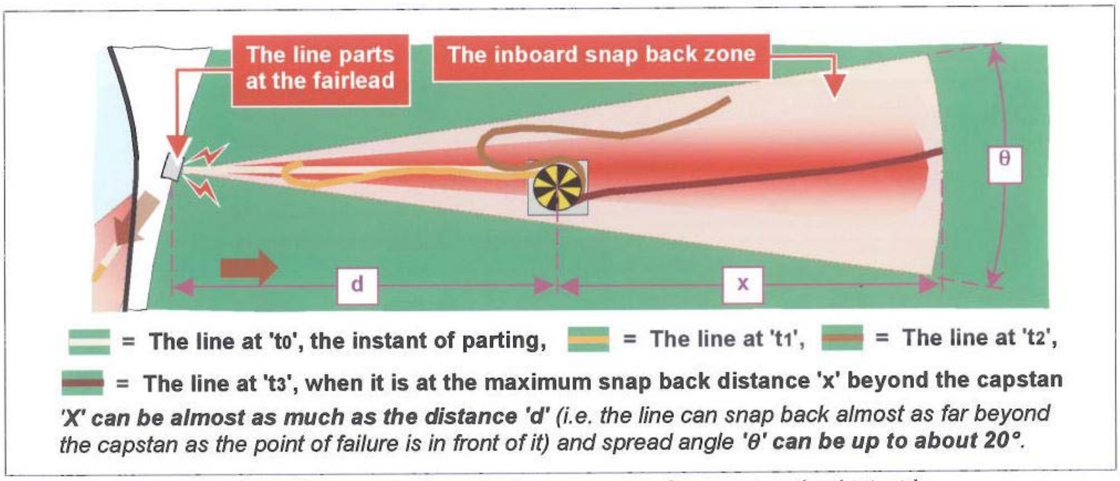
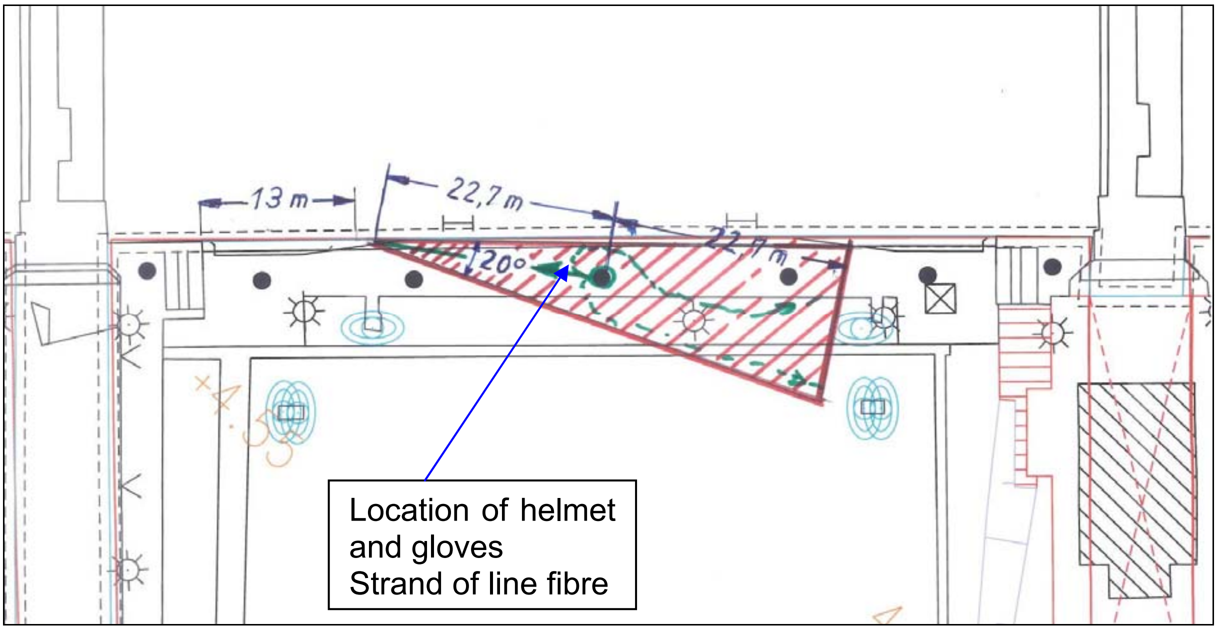


Fig. 5.20 The snap back zone when a mooring line parts at the ship's side

Figure 38: Danger area when a line breaks

Seen from the position of failure, the literature indicates that the angle can be up to 20° and the line snaps back beyond the winch in its length from winch to position of failure (x=d).
Similarly, the line snaps back at the same angle away from the vessel beyond the bollard in its length from the position of failure to the bollard on shore.

Application of the empirically established values discussed above to the situation on the day of the accident, with the length of the discovered line of 22.70 m, results in the following danger area, in which the linesman must have been situated.



The section marked red around the bollard shows the danger area of a line snapping back after it breaks.
Besides the typical wounds of a leg injury caused by a line, it is certain that the deceased linesman was working in this area, to the left of the bollard, when one considers that his helmet and gloves were found in the danger area to the left of the bollard (see Fig. 5).

4.5 Lifejackets

The lifejacket had apparently ridden up the body of the deceased and he was therefore supported with his head under water. It may have ridden up due to an unclosed or loose belt; however, this was not confirmed by the witnesses. In the case of a fall of more than 5 m, it is also possible that the lifejacket rode up when striking the water or wooden boom.
The lifejacket was otherwise technically sound and automatically inflated by means of a hydrostatic release unit.

The SECUMAR BS 16 lifejacket worn conforms to the DIN EN ISO 12402-3[6] (FN, Lifejackets, performance level 150) standard. The buoyancy of this lifejacket is at least 150 N and it is *"designed for general use or use with a weather-proof oilskin. A lifejacket of this performance level rotates the body of an unconscious person to a safe floating position and no further action is required by the user to maintain this position.*"
The next and highest class for lifejackets is performance level 275 according to DIN EN ISO 12402-26[7]. "The buoyancy of this lifejacket is at least 275 N and *it is primarily for use in extreme conditions in deep sea areas. It is also suitable for users who wear clothes in which air can accumulate and impair the self-righting capability of the lifejacket.*

[6] According to EN ISO 12402 Part 3 Lifejackets for normal operations (performance level 150)
[7] According to EN ISO 12402 Part 2, 2006 Lifejackets for extreme conditions (performance level 275)

This performance level is intended to ensure the user floats in a safe position with mouth and nose above the surface of the water."

Lifejackets should rotate the body of a person in the water to a safe floating position in which the head is sufficiently above water. Normal clothing that is permeable to air and water as well as the human body does not represent a problem. However, modern, breathable weather-proof clothing is problematic for a performance level 150 lifejacket. The resistance to rotation is increased by such clothing due to air and water impermeable membrane and waterproofing materials, meaning that an unpredictable, uncontrolled inherent buoyancy acts against the rotation of a person to a safe position with the face uppermost. Performance level 275 lifejackets are a further development and provide enhanced safety against drowning when unconscious also when breathable weather-proof clothing is worn.

It is of crucial importance to the proper functioning of all life jackets that they fit and are worn properly. When falling into the water, a loose belt can lead to the lifejacket riding up the body or a loss of buoyancy. Too large, too small or improperly worn lifejackets can be dangerous for the wearer. A lifejacket must therefore sit firmly on the body but at the same time permit the necessary freedom of movement.

However, attention should also be given to Notice BGR 201 of the Berufsgenossenschaft der Bauwirtschaft (the statutory accident and insurance prevention institution in the building trade in Germany): 'Use of personal protective equipment to prevent drowning' "(...) *Impairment and obstruction caused by personal protective equipment designed to prevent drowning during the normal activity of the user must be avoided, in particular, to ensure its acceptance in daily use. With that in mind, preference should be given to lifejackets that are lightweight but have sufficient buoyancy, are not unnecessarily bulky and permit free movement. It follows that, e.g. non-inflatable lifejackets and harnesses should not be used in the commercial sector."*

4.6 Maritime medical aspects

The Hamburg Port Health Centre (Head: Dr Schlaich), Central Institute of Occupational Medicine and Maritime Medicine, which assisted in the marine casualty investigation, referred to aspects of occupational, maritime and emergency medicine. In that respect, a review of the working procedures and occupational safety from the perspective of occupational health in the form of a risk analysis, e.g. of the following points, appears to be necessary:

- Equipment (functionality and implementation of the lifejackets and other protective clothing). Why was the casualty not wearing protective ankle boots? Was the lifejacket suitable and worn properly (protection in case of unconsciousness)?
- Communication (use of radio equipment, access to emergency telephone, communications between vessel and lock personnel?)
- Accessibility (would it have been more appropriate to use a rescue helicopter?)
- Recovery from fender (availability of a rescue davit?)

- Initial treatment procedures (are these practised during emergency exercises; do corresponding operating instructions exist?)
- Restricted visual contact between the two linesmen due to the middle gate
- Precautionary medical checks (e.g. examination of twilight vision)
- Basic qualification and training of personnel

As regards the emergency and maritime medical aspects, it was noted that the lock supervisor was promptly alerted by the pilot on board. Beyond that, initial treatment on board using the existing emergency equipment did not take place and in the view of the doctor was not called for. It is predominantly the shore-based rescue chain on which demands are placed and that should be closely scrutinised in terms of the way it functions.

4.7 Action taken

The accident was dealt with on shore by the Unfallkasse des Bundes (federal accident insurance fund) within the framework of an investigation report. Recommended action was that the annual training for the lock service should be adapted to account for the danger of breaking lines according to the situation and that the training should be carried out more frequently.

As a result of the accident, the 'Leinenbrüche am Nord-Ostsee-Kanal (line failures in the Kiel Canal)' working group was set up, which presented its final report in February 2010. In outlining the issue for the working group, it is explained that the lock personnel at both NOK locks are constantly exposed to the risk of being struck by a broken line and that this constant threat is unacceptable. Furthermore, it states: *"Increased training and awareness of the lock personnel alone cannot solve the problem permanently. Rather, secondary occupational safety measures must be taken to protect the lock personnel against lines which are out of control after breaking."* The working group considered, examined, in part rejected as impractical and finally, for example, made proposals which are open-ended as regards outcome:

- Review of the risk and exposure assessments
- Rules of conduct to be considered in case of emergency
- Improve communication between pilots and linesmen
- Procurement of technical equipment for emergencies (rescue davit with stretcher, lifeboat with flap)
- Provision or modernisation of shelters as appropriate
- Optimisation of bollards
- Improve overview of the area; middle gates should be removed from locks during renovation work
- Protective barrier and safety paths
- Better or other protective clothing, protective ankle boots (S3), N275 lifejackets

5 CONCLUSIONS

The fatal accident happened in the Brunsbüttel Lock as the TMV LISTER, which was slightly behind, was the first vessel to sail from the lock. While she was departing, the TMV COVADONGA, which was moored opposite, was first propelled backward and then forward. The fore spring broken during the forward movement.
This accident is the result of a chain of several events and could have been avoided had certain factors which facilitated it been eliminated. After completing the investigation, the BSU has arrived at the following accident sequence and possible preventive measures for such or similar incidents:

1st factor
The TMV LISTER is moored with her stem about 30 m behind the stem of the TMV COVADONGA and is the first vessel to sail from the lock. To cast off and accelerate the rates of speed 'dead slow ahead' and later 'slow ahead' are selected. This casting off manoeuvre inevitably sets water in motion, which impacts other vessels in the lock.
→ *If the vessel in front, in this case the COVADONGA, would have been the first vessel to depart, interaction between the two vessels would not have persisted for so long*
→ *Use of the lowest engine rating necessary for safe manoeuvrability*
→ *Use of the bow thruster with the utmost caution and lowest power*
→ *Adequate monitoring of interaction with other vessels*

2nd factor
The TMV COVADONGA is made fast only with a long fore spring as well as a head line and stern line, which are only deployed as breast lines. The COVADONGA is initially pulled astern due to hydrodynamic suction, during which the head line and stern line are automatically slackened by the winches. The COVADONGA is then dragged forward by the passing TMV LISTER.
→ *It is necessary to make fast 1:1 (head line, fore spring, stern line, aft spring) when several vessels are in the lock and there is interaction with outgoing or incoming vessels*
→ *Mooring lines are to be kept taut at all times*

3rd factor
When the vessel moves astern, the fore spring loosens and sags over the edge of the lock. It cannot be excluded that during the subsequent forward motion the fore spring was stretched to the damaged safety recess cover and chafed there until it broke. The linesman was struck on the leg by the broken line and thrown from the lock wall.
→ *The possibility of a line snagging or chafing on sharp edges on the lock wall must be excluded; damaged areas are to be cordoned off and/or repaired immediately*

→ *As a basic principle, people should enter the danger area of lines as little as possible; the risk of the lines of a vessel which is already moored breaking due to other outgoing or incoming vessels also exists*

4th factor
The linesman is wearing a lifejacket which does not rotate his body to a safe position at all times when unconscious and wearing work clothing.
→ *Equip the linesmen with N275 lifejackets to better establish a safe position when unconscious*
→ *Ongoing and recurrent instruction and training of the linesmen in wearing lifejackets correctly*

To minimise the risk of accidents while linesmen are carrying out tasks in the danger area of breaking lines or tasks by the water which a involve a risk of falling, it is necessary to determine and implement the necessary occupational safety measures to reduce danger within the framework of permanent risk identification and risk assessments.
The Federal Bureau of Maritime Casualty Investigation, which is responsible only for the safety of shipping, including the inextricably linked occupational safety and health of workers on seagoing vessels, shall make no further recommendations for the occupational safety of shore-based employees.

6 Safety recommendations

The following safety recommendations do not attribute a presumption of blame or liability in respect of type, number or sequence.

6.1
The Federal Bureau of Maritime Casualty Investigation recommends that the **Lotsen der Lotsenbrüderschaft NOK I** (Brotherhood [sic] of NOK I Pilots) advise ship's commands that regardless of size vessels should be made fast at least 1:1 (head line, fore spring, stern line, aft spring) in locks with several vessels and interaction caused by suction and swell.

6.2
The Federal Bureau of Maritime Casualty Investigation recommends that the **Lotsen der Lotsenbrüderschaft NOK I** advise ship's commands that vessels departing from the locks in Brunsbüttel should be set in motion with minimum use of the main engine and bow thruster and that attention is to be paid to interaction with vessels which are still moored.

6.3
The Federal Bureau of Maritime Casualty Investigation recommends that the **ship's command of the COVADONGA** ensure that mooring lines are kept taut at all times.
This recommendation also applies, in principle, for other vessels with similar mooring winches which only slacken automatically when under excess load and are tightened manually by the winch operator.

6.4
The Federal Bureau of Maritime Casualty Investigation recommends that the **Waterways and Shipping Directorate North and the relevant waterways and shipping authority offices in Brunsbüttel and Kiel** work towards ensuring that damage in the area of locks on which mooring lines may chafe or get caught is immediately rectified resp. the areas set aside for making fast vessels are cordoned off as breaking lines endanger both people on shore and workers on board seagoing vessels.

7 Sources

- Investigations by the waterway police (WSP)
- Written statements
  - Ship's command
  - Vessel operator
  - Classification society
- Witness accounts
- Expert opinion
  - Investigation report of the Unfallkasse des Bundes (federal accident insurance fund), Occupational Safety and Prevention of 25 November 2008
  - Opinion on the fatal occupational accident, Central Institute of Occupational Medicine and Maritime Medicine, Hamburg 5 May 2010
  - Final report by the Leinenbrüche am Nord-Ostsee-Kanal (line failures in the Kiel Canal) working group, dated 17 February 2010
  - Expertise on the cause of a line failure, Plass Engineers, 6 February 2010

  Specialist literature
  Seemannschaft 3, Schiff und Manöver (Seamanship 3, Ship and Manoeuvre), VEB Verlag für Verkehrswesen
  The Nautical Institute.
  1. Mooring and Anchoring of Ships Vol. 1, Principles and Practise, October 2009, ISBN No. 978 1 906915 934
  2. Mooring and Anchoring of Ships Vol. 2, Inspection and Maintenance, September 2009, ISBN No. 978 1 870077 941
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- Official weather report by Germany's National Meteorological Service (DWD)
- Radar plots, Vessel Traffic Services (VTS)/Vessel Traffic Centres
- Documentation from the Ship Safety Division (BG Verkehr)
  - Accident Prevention Regulations for Shipping Enterprises (UVV-See)
  - Guidelines and codes of practise
- Documentation, Berufsgenossenschaft der Bauwirtschaft (the statutory accident and insurance prevention institution in the building trade in Germany/BG Bau)
- Standards DIN EN ISO 12492- ff Personal flotation devices