Bundesstelle für Seeunfalluntersuchung
Federal Bureau of Maritime Casualty Investigation
Federal Higher Authority subordinated to the Ministry of Transport
and Digital Infrastructure

Investigation Report 266/14

Serious Marine Casualty

Foundering of PONTON 1
on 13 August 2014
north of Darßer Ort

12 August 2015

The investigation was conducted in conformity with the Law to improve safety of shipping by investigating marine casualties and other incidents (Maritime Safety Investigation Act – SUG) of 16 June 2002, amended most recently by Article 1 of 22 November 2011, BGBl. (Federal Law Gazette) I p. 2279.

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 (Article 9(2) SUG).

This report should not be used in court proceedings or proceedings of the Maritime Board. Reference is made to Article 34(4) SUG.

The German text shall prevail in the interpretation of this investigation report.

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1 Summary

At about 0432[1] on 13 August 2014, the German-flagged tug BÖSCH and the PONTON 1 were proceeding from the Volkswerft shipyard in Stralsund to Rostock when the officer on watch noticed that the pushed PONTON 1 was developing a list to port.
He woke all of the other three crew members and the master reportedly sent the nautical officer and the seamen onto PONTON 1 to identify the cause of the list. No water ingress could be found, however.
The increasing list caused the mooring lines between the BÖSCH and the PONTON 1 to part shortly after.
Assistance was requested on VHF at 0455. The multipurpose ship ARKONA and rescue cruiser THEO FISCHER reached the pushed convoy about half an hour later. A joint attempt was made to tow the PONTON 1 into shallow water. It was no longer possible to put the plan to use bilge pumps into effect, as the PONTON 1 capsized at 0650 and then foundered at 0710.
The cargo was so well secured that it stayed in its position until the subsequent salvage of the PONTON 1 on 26 August 2014.
There were neither injuries nor environmental pollution. It was still possible to use the cargo and the PONTON 1 was returned to service after she was repaired.

[1] Unless stated otherwise, all times shown in this report are local = UTC + 2 (CEST).

2 FACTUAL INFORMATION

2.1 Photo

ã WSP

Figure 1: Tug BÖSCH

2.2 Ship particulars: BÖSCH

Name of ship:	BÖSCH
Type of ship:	Tug
Nationality/Flag:	German
Port of registry:	Hamburg
IMO number:	8861022
Call sign:	DIYB
Owner:	Robert Krebs KG (GmbH & Co.)
Year built:	1931
Shipyard/Yard number:	Norderwerft AG, Hamburg/666
Classification society:	GL
Length overall:	28.28 m
Breadth overall:	7.70 m
Gross tonnage:	119
Deadweight:	35 t
Draught (max.):	3.1 m
Engine rating:	736 kW
Main engine:	Klöckner-Humboldt-Deutz AG Diesel RBV 8 M 545
(Service) Speed:	11 kts
Hull material:	Steel
Hull design:	Ice-strengthened
Minimum safe manning:	4

2.3 Photo

© BSU

Figure 2: PONTON 1

2.4 Ship particulars: PONTON 1

Name of ship:	PONTON P1
Type of ship:	Transport pontoon without a propulsion system
Nationality/Flag:	German
Port of registry:	Hamburg
IMO number:	-
Call sign:	DGOX
Owner:	Hans Schramm & Sohn GmbH & Co. KG
Year built:	1966
Shipyard/Yard number:	Carl Spaeter GmbH/6491
Classification society:	GL
Length overall:	35.0 m
Breadth overall:	11.2 m
Gross tonnage:	168
Deadweight:	260 t
Draught (max.):	1.01 m
Engine rating:	-
Main engine:	-
(Service) Speed:	-
Hull material:	Steel
Minimum safe manning:	0

2.5 Voyage particulars of the pushed convoy

Port of departure:	Stralsund
Port of call:	Rostock
Type of voyage:	Merchant shipping National
Cargo information:	4 x 10 t wind turbine platforms
Manning:	4
Draught at time of accident:	Tug: 3.0 m, PONTON 1: 0.85 m
Pilot on board:	No
Canal helmsman:	No
Number of passengers:	0

2.6 Marine casualty or incident information

Type of marine casualty:	Serious marine casualty: Foundering (and salvage) of the PONTON1
Date, time:	13/08/2014, 0745
Location:	North of Darßer Ort
Latitude/Longitude:	φ 54°29.67'N λ 012°27.56'E
Ship operation and voyage segment:	Coasting
Place on board:	Pushed pontoon
Consequences (for people, ship, cargo, environment, other):	No injuries or harm to the environment; pontoon with cargo salvaged and repaired

Excerpt from Nautical Chart 3005, BSH

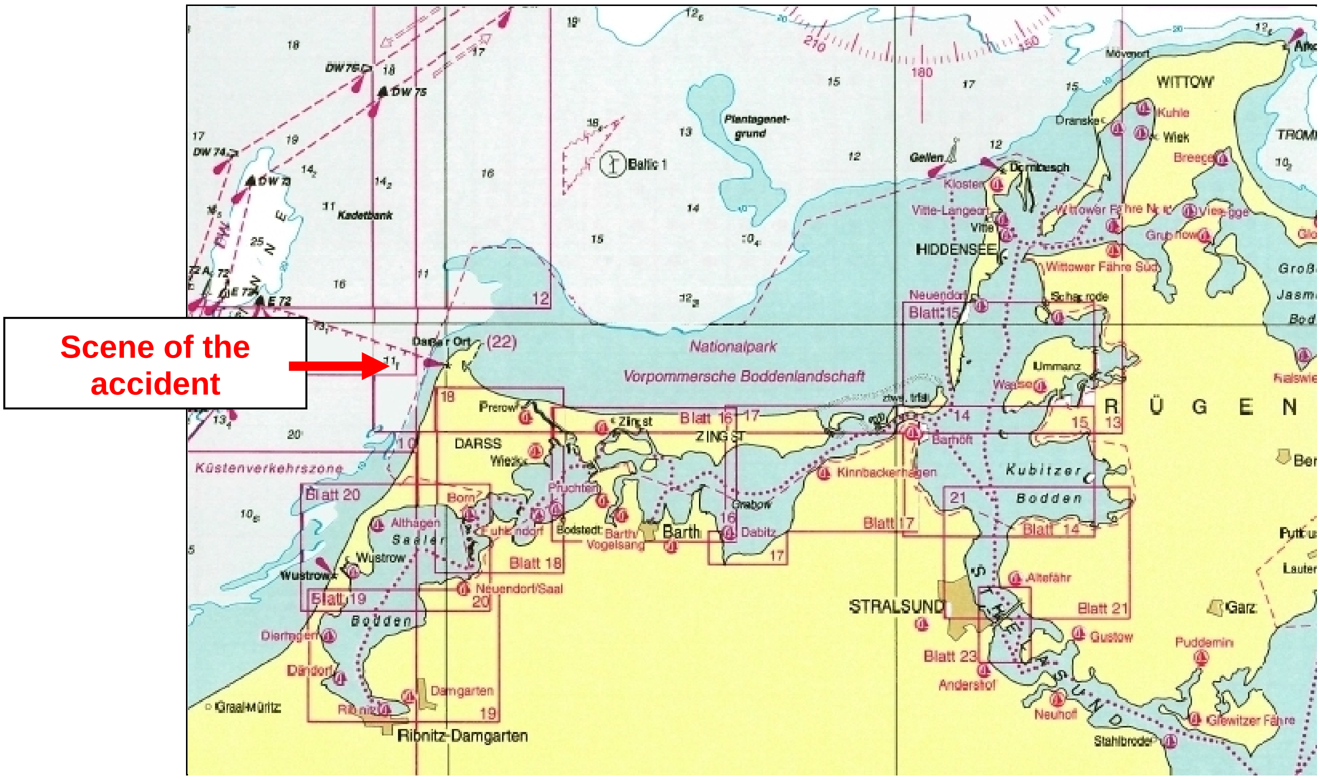

Figure 3: Nautical chart

2.7 Shore authority involvement and emergency response

Agencies involved:	Vessel Traffic Service (VTS) Warnemünde, German Maritime Search and Rescue Service (DGzRS), Waterway Police (WSP) Rostock
Resources used:	MPV ARKONA, Rescue Cruiser THEO FISCHER; Coastal Protection Boat WARNOW
Actions taken:	Restore towing connection, attempt to move into shallow water, attempt to use bilge pumps
Results achieved:	PONTON 1 foundered at a water depth of about 10 m

3 COURSE OF THE ACCIDENT AND INVESTIGATION

3.1 Course of the accident

PONTON 1 was loaded with four platforms for offshore wind turbines in the course of 12 August 2014. The tug BÖSCH was attached as a pusher to the push-plate on the aft end of the PONTON 1.
The pushed convoy cast off from Berth 27 at the Volkswerft shipyard in Stralsund after the lashing was inspected at 1700. This was the ninth time that structural parts had been transported in this manner to Rostock for assembly.

Figure 4: Example of the pushed convoy departing

Weather conditions were good and a SW wind of 3-4 Bft prevailed.
There were four people on board: the master, an officer in charge of the navigational watch (OOW), a technical officer, and an able-bodied seaman (AB). The OOW was on duty until 1800 and the master then took over until midnight. The OOW was scheduled to take over the watch again from midnight until 0600. According to the log book entry, he noticed that the PONTON 1 had a bow-heavy list to port at 0432. He informed all the other crew members and the master took over the watch on the bridge. He instructed the OOW and the AB to carry out a visual inspection on PONTON 1. It was not possible to identify any damage that could have caused the apparent water ingress. However, they did not climb into the PONTON 1's void.
The PONTON 1 veered to starboard due to the increasing list, causing the cable and the two mooring lines to part on the port side at 0447. The PONTON 1 reacted to that by rolling onto her port side.

At 0455, VTS Warnemünde was notified on VHF channel 72. The VTS assured that assistance would be provided and called MPV ARKONA and the rescue cruiser THEO FISCHER. MPV ARKONA reached the tug and tow at 0520. After an initial consultation between the two ship's commands, it was decided that the BÖSCH would establish a towing connection with and attempt to pull the ever deeper sinking PONTON 1 to shallow water. At the same time, they were aware that the protection zone near Darßer Ort should be avoided.

ã MPV ARKONA

Figure 5: Towing connection

It was no longer possible to put the plan to use bilge pumps into effect, as the PONTON 1 capsized over her port side at 0650 and then floated on her longitudinal side. The cargo was so well secured that it remained on deck virtually undisturbed.

ã MPV ARKONA

Figure 6: The PONTON 1 has capsized

The towline parted at 0710 and the PONTON 1 sank to a depth of some 10-12 m at 0745. Two lines had been attached prior to that, each with a red buoy attached to its end, and the scene of the accident was thus kept visible on the surface.

ã MPV ARKONA

Figure 7: The PONTON 1 has foundered

The BÖSCH let go her anchor at 0755 to remain at the scene. Figure 8 shows the course of the entire voyage of the pushed convoy from leaving the Volkswerft shipyard until the PONTON 1 foundered. It can be concluded after a detailed analysis of the position data that no shallows were passed.

ã Vesseltracker.com

Figure 8: AIS track of the course of the voyage

3.2 Investigation

3.2.1 Tug BÖSCH

The BÖSCH was built by Norderwerft AG and put into service as the pilot steamer 'Böschlotse' for the Hamburg pilots in 1931.
In 1965, the Brunsbüttel-based company Hans Schramm had the ship converted into the tug. Inter alia, the main engine was converted from steam to diesel.
In 1974, the main engine was replaced by one that was more powerful and as a consequence of that the propeller also had to be adapted.
In 1999, the tug was completely overhauled for maintenance of the class, which also entailed replacing the DC generator with a new three-phase generator.
In 2001, the existing auxiliary diesel engine was replaced with a modern engine. This system is used to drive the capstan and the mooring winch.
All necessary certificates and documents were present at the time of the accident and did not warrant any criticism.

3.2.2 PONTON 1

After the pontoon was built in 1966 and put into service, the owner requested authorisation from the classification society, Germanischer Lloyd, to weld the manholes on the main deck and install doors in the transverse bulkheads in place of them as early as in 1967. The interior of the pontoon was to be accessed via a manhole at each end. GL authorised this with the proviso that the transverse bulkhead doors be permanently closed and opened only for a short period when necessary.
In 1975, conversion to a 'Seebeck push system' was requested. This was authorised and made it possible to install a push-plate on the end of the pontoon. GL had concerns in that it was reportedly unable to assess the weather in which pushing was possible and felt that pulling would also be necessary at times.
Here too, all necessary certificates and documents were present at the time of the accident and did not warrant any criticism.

3.2.3 Salvage

All sides had already confirmed their intention to salvage PONTON 1 shortly after she foundered on 13 August 2014; however, the weather obstructed this for days. The floating crane SAMSON and the tug OBELIX arrived at the scene of the accident on 26 August 2014. Divers began to pull towing cables under the pontoon.
The pontoon was turned under water and then brought to the surface in the afternoon.

ã Owner

Figure 9: PONTON 1 being salvaged

ã Owner

Figure 10: PONTON 1 salvaged

The push tow started to move in the evening and arrived at Rostock early in the morning of 27 August 2014.

The BSU's investigators and the WSP arrived at the Nordic Yard (formerly Warnowwerft) shipyard at about 1100. As an expert in materials testing, Professor Happ from the Institut für Werkstoffkunde und Schweißtechnik Service GmbH (*Institute of Materials Science and Welding Technology*) was also present.
About 20 people – including representatives of various insurance companies, the shipyard, the Danish salvage company, the owner of the cargo, as well as the operators of the tug and of the pontoon – waited on the pier for the situation to unfold. Unfortunately, it was not evident for a long period when the decision in favour of this shipyard would be taken and, if so, when and where the pontoon would be put down.
Approval to put down the pontoon at berth 10 of the Nordic Yard in Warnemünde was finally given at about 1500. It took another two hours until the pontoon was finally put down. There were no complications when she was lifted out. However, it was necessary to wait until the water that had entered drained out through the cracks caused by the salvage cables.

ã BSU

Figure 11: PONTON 1 is put ashore

The apparent leak was about 13.5 m from aft and about 1.40 m from the starboard side. The inward dent was virtually round and deeper towards the middle, where the maximum depth measured was about 13 cm. The length of the crack was about 8-10 cm there and bent.
Paint had flaked off in the vicinity of the dent and the pontoon's steel looked dark grey. It was evident that scale was still firmly adhered to the surface of the steel. Loose rust deposits had formed on this scale.
The ridges in these areas point to a metallic object that may have caused them. Paint residues from another source were not found, however.

Figure 12: Leak in the bottom of the PONTON 1

The pontoon was ultimately released and the investigators were able to go on deck. The cargo, consisting of four platforms to enable access to a wind turbine, slipped only slightly and was hardly damaged. Each of these rings weighed about 10 t. The railing around the pontoon was deformed more than anything else.

Figure 13: Damage on deck

Numerous photos and videos were made. Two investigators then climbed inside the pontoon and made a record of the actual condition.

There are four transverse bulkheads, which can be accessed through watertight doors. Each bulkhead has a door on both sides. Each second door was open (starting at forward port open, starboard closed). The longitudinal bulkhead in the middle of the pontoon is used only for stabilisation. Consequently, it is not watertight and has a number of openings. Blackening's were visible on certain sliding bolts in the bulkheads, indicating that the bolts had been made serviceable with an open flame.

ã BSU

Figure 14: View inside

All the seals found on the supposedly watertight doors (see Figure 15) were defective (brittle, incomplete).
The manholes on the main deck for entering the various compartments from above were welded closed (see Figure 16).
Apart from the section with a leaking bottom, everywhere in the pontoon was under water on only the next day. This means that the bottom plating is watertight.

The PONTON 1 was repaired in the days that followed and later returned to service.

ã BSU

Figure 15: Internal door (bulkhead)

ã BSU

Figure 16: Example of a manhole welded closed

4 ANALYSIS

4.1 Calculation of the inflowing water mass

According to the Handbuch für Schiffssicherheit (*manual for ship safety*)[2], the inflowing mass of water is calculated as follows:

$V = A * \mu * (\sqrt{2gh}) * 3600 = \ldots m^3/h$

The following applies:
A: Area of the leak
g: 9.81
h: Height of the area above the leak
μ: Contraction coefficient = 0.66 (crack) / 0.97 (hole)
3600: Conversion from second to hour

$((0.05\ m * 0.003\ m) * 0.97 * (\sqrt{(2 * 9.81 * 1.2\ m)})) * 3600 = 0.00015\ m * \sqrt{23.54} * 3600 = 0.00015 * 4.85 * 3600 = 2.54\ m^3/h$

The pontoon's volume is
$35.0\ m * 11.2\ m * 1.70\ m = 666.4\ m^3 / 2.54\ m^3/h = 262.36\ h / 24\ h =$ **10.9 days**

Theoretically, it would thus take at least 10.9 days for the entire pontoon to fill via the crack.

It was reported that the pontoon rolled heavily during the last voyage. In the process, the leak's extent of immersion would increase but then reduce again. Consequently, significant changes in the leak rate are not expected initially.
However, the rolling motion increases significantly due to the water that has entered and if the pontoon heels to the extent that water runs over the deck, there is a possibility that it would run into the anchor's chain locker at the bow of the pontoon. If the pontoon's interior is more than half-filled with water, her centre of gravity is so low that the rolling motion should reduce again.
Such a rapid ingress of water at the same time as a rolling motion would also be consistent with the fact that the pontoon capsized when she foundered.
Indeed, it is likely that the leakage found is the primary cause of the pontoon foundering, but it is not directly related to the time at which the leak formed. The increased rolling motions indicate that a large amount of water must have already been in the space during the last voyage.

[2] Published by Professor J. Hahne, Seehafen Verlag GmbH, 2006, first edition, ISBN 3-87743-815-6, page 215

4.2 Stability calculation

"The basic parameters for the stability of a ship are the centre of gravity and the centre of lift (also centre of buoyancy), as well as the resulting metacentric height. The longitudinal centre of gravity can be viewed as the entire weight of the ship acting downwardly on a single point. When the ship heels, the position of the longitudinal centre of gravity within the ship remains undisturbed, provided that the position of any mass inside her does not change (for example, the longitudinal centre of gravity changes if cargo moves). The centre of lift can be viewed as the entire weight of the displaced water acting upwardly. Its position changes when a ship heels because the 'shape' of the displaced water changes.

When the ship is floating in an upright position, the centre of lift is vertically aligned with and below the longitudinal centre of gravity. If the ship heels due to an external factor, the longitudinal centre of gravity does not move in relation to the ship, but generally shifts to the side of the heel. The centre of lift shifts to the same side, i.e. to the centre of the now displaced water. If the longitudinal centre of gravity and centre of lift are no longer vertically aligned, and the longitudinal centre of gravity is below the original metacentre of the ship, then a so-called righting lever forms, which returns the ship to her initial position when the factor causing the heel is removed."

(Source: Wikipedia, 25/06/2015)

The Institute of Ship Design and Ship Safety of the Hamburg-Harburg University of Technology (TUHH) quantified the incident and simulated it on a computer.

Estimated values

Displacement of the empty pontoon (according to technical documents)	:	135 t
Mass of the cargo (four offshore platforms)	:	42 t

Pontoon's centre of gravity
xcg = 17.5 m
zcg = 1.27 m
ycg = 0 m

(xcg, zcg, and ycg are the distances to the pontoon's longitudinal centre of gravity in three levels)

Cargo's centre of gravity

The data were taken from the tow's planning documents (each tow is calculated theoretically beforehand by a consulting company specialised in this field to determine the cargo and securing thereof for transportation).

To simplify matters, the TUHH applied a rectangular frame for the pontoon with a width of 11.2 m.

Original floating position
The estimated values result in a level floating position with a draught (D) of 0.45 m.

Results achieved:
Since the pontoon's trim was low when she was capsizing, it is assumed that the liquid was distributed evenly across her entire length. The free surfaces are taken into account.

With 47 t of water in the pontoon the floating condition is stable, i.e. she still has a GM[3] of 6 m and a sufficient area under the righting lever arm curve (see Figure 17).

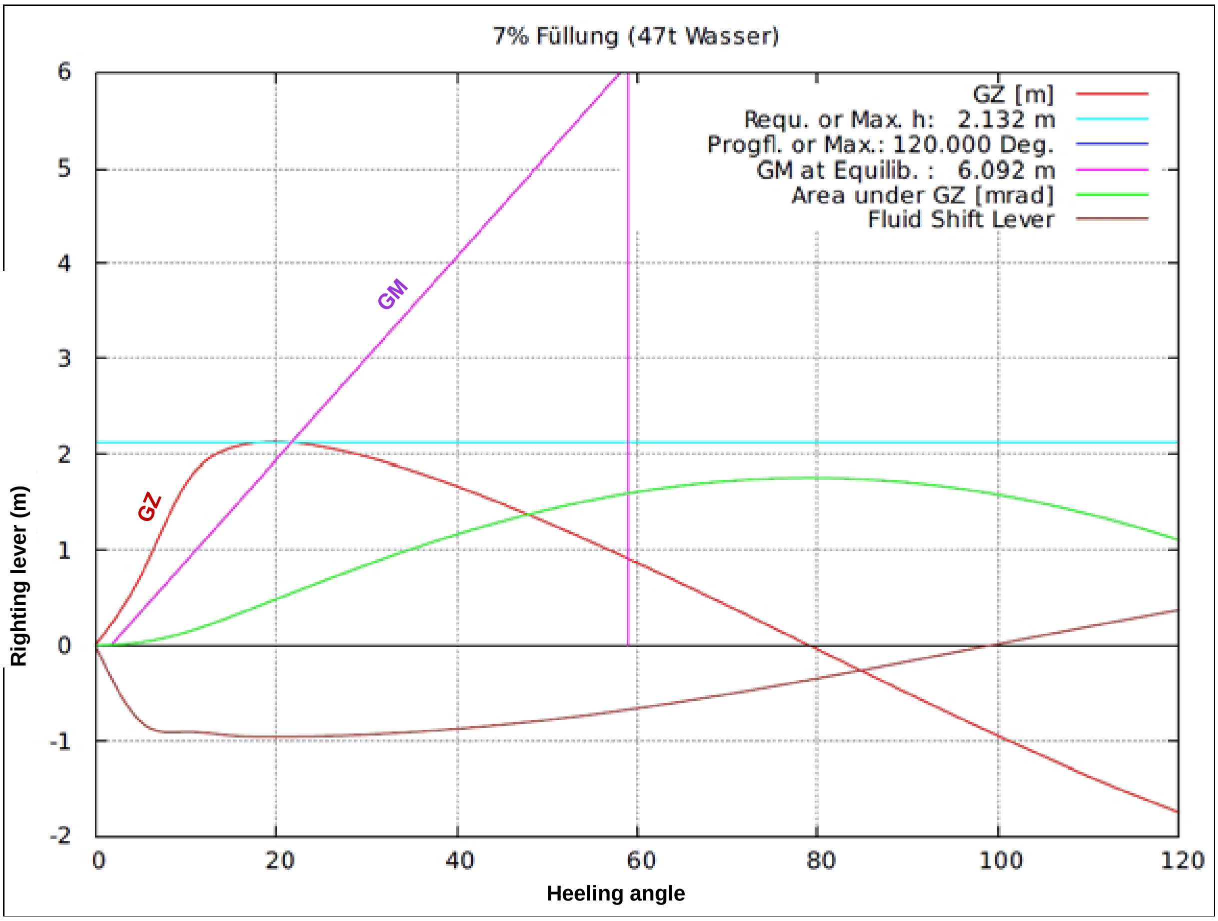

Figure 17: Righting lever arm curve at 47 t of water

[3] The distance from the centre of mass (G) to the metacentre (M) is referred to as metacentric height (GM). The centre of gravity (G) of a floating body is positioned vertically below the metacentre, unless external forces or moments are acting on the body. This means that the body moves until this condition is met. The metacentric height is of importance when assessing stability at low heeling angles. It can be ascertained by an inclining test, making it possible to determine the position of the centre of gravity. An estimation of the metacentric height can also be derived from the roll period (roll test). (Source: Wikipedia, 25/06/2015)

When the pontoon is 20% (137 t of water) full, a condition arises in which she tends to roll back and forth between the two equilibrium positions. This would explain the rolling motion during the last voyage (see ⯃ in Figure 18).

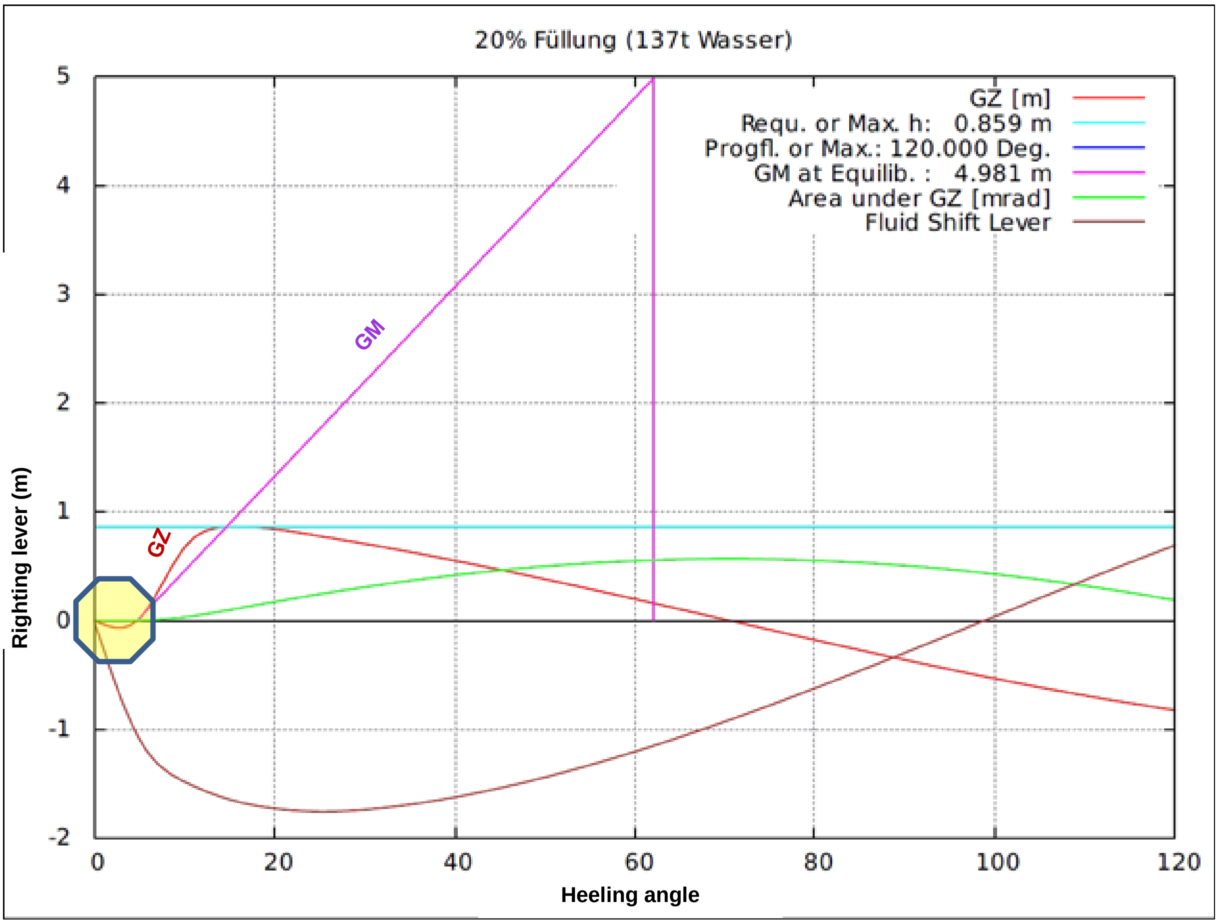

Figure 18: Righting lever arm curve at 137 t of water

The pontoon will roll over when she is 34% (232 t of water) full (see ⯃ in Figure 19: Righting lever arm curve[4] and Figure 20: Floating condition).
If we now assume a rate of inflow of 2.54 m^3/h, the result is:

232 t : 2.54 m^3/h = 91.34 h : 24 h = 3.8 days

This means the leak must have formed at least 3.8 days before the accident.

[4] Knowledge of the metacentric height is generally not sufficient when assessing the stability of a ship. Rather, the entire righting moment curve over the heeling angle is important. To obtain a value independent of ship size, the righting moment is divided by the weight of the ship, thus delivering the righting lever. It is equal to the centre of gravity's distance from the lift vector. The metacentric height (GM) is equal to the pitch of the tangent on the curve at the zero point. (Source: Wikipedia, 25/06/2015)

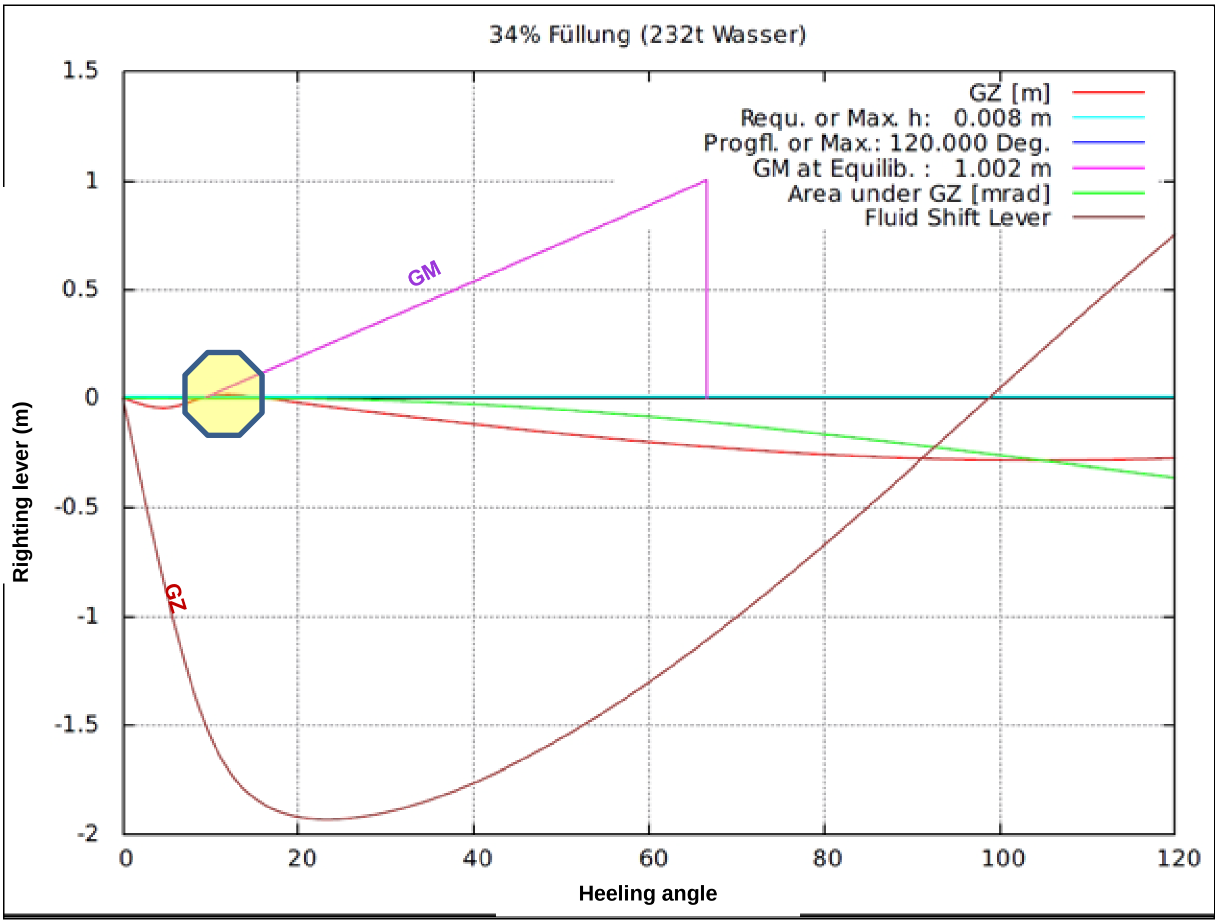

Figure 19: Righting lever arm curve at 232 t of water

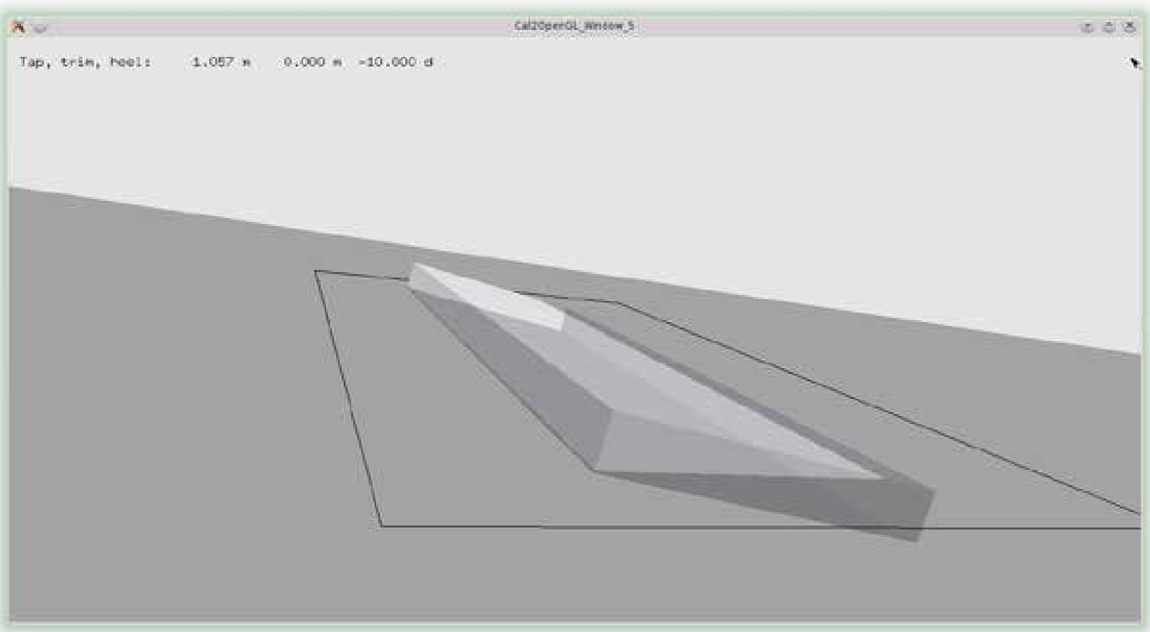

Figure 20: Floating position at 232 t of water

After the pontoon rolled over, water continued to enter through various other openings, resulting in an equilibrium position of about 110° when she was 50% (340 t of water) full (see in Figure 21: Righting lever arm curve and Figures 6 and 22: Floating position). This explains the floating position on the pontoon's longitudinal side.

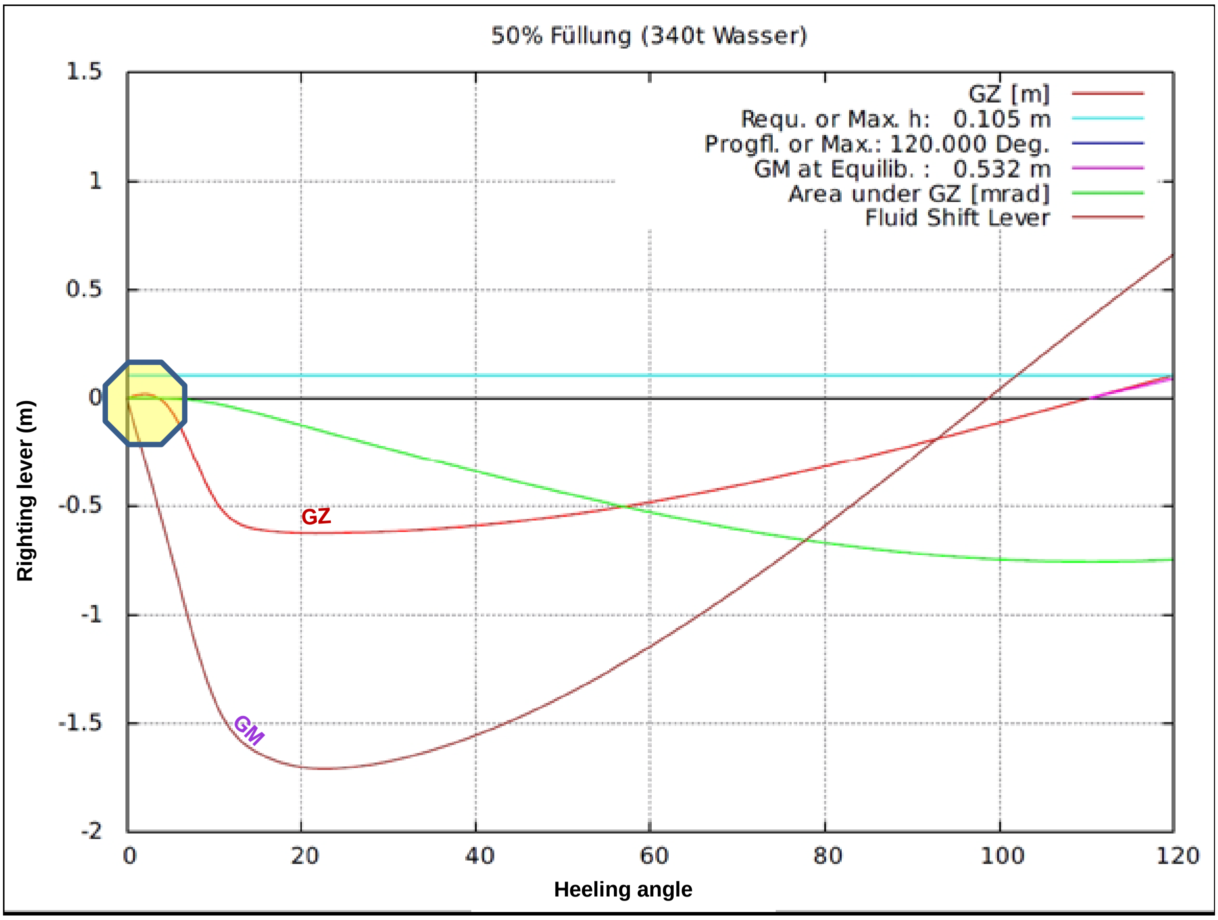

Figure 21: Righting lever arm curve at 340 t of water – capsize

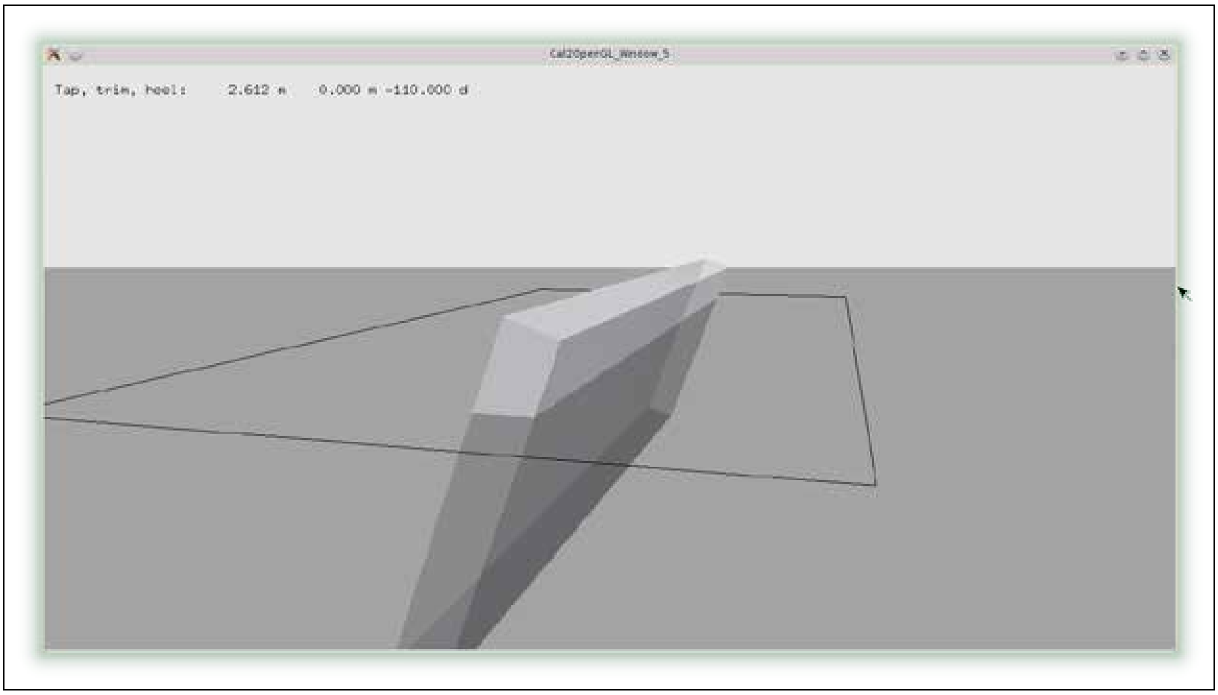

Figure 22: Floating position at 340 t of water

Result of the calculation

Based on the leak found in the bottom of PONTON 1, she must have already been at least 20% full with water before the voyage. Mathematically, the original draught would then be 0.8 m, which would correspond with the draught specified at the time of the accident. She would be prone to slight rolling motions in this condition. An additional 90 t of water or so would have to have entered during the voyage for the pontoon to capsize. This is consistent with the duration of the voyage up until the event occurred.

4.3 Watertight integrity

Apart from being stated in various rules and regulations[5], common sense also tells every seaman that he should caulk his ship such that she does not fill with water and thus be exposed to the risk of foundering.

When PONTON 1 was converted in 1967 such that the manholes on the main deck were closed and, in place of those, doors were used in the internal transverse bulkheads, GL approved this with the proviso that the doors in the transverse bulkheads be permanently closed and opened only for a short period when necessary.
Each second door was open at the time of the accident. Added to that is the fact that the longitudinal bulkhead in the middle of the pontoon is used only for stabilisation and therefore not watertight. This makes water ingress even more dangerous, as the free surface in this area is increasing constantly.
Soot deposits were visible on certain sliding bolts in the bulkheads, indicating that the bolts had been made serviceable with an open flame. It is evident that these sliding bolts were very rarely used.
Even if the doors were closed, the worn seals on the supposedly watertight doors would not be capable of keeping out water completely.

[5] See Article 13(2) of the Schiffssicherheitsverordnung (Germany's ordinance on the safety of seagoing ships), inter alia.

5 CONCLUSIONS

It was no longer possible to establish exactly when the leak in the bottom of the PONTON 1 formed and what caused it. Due to the relatively low inflow, it must have formed at least 3.8 days before the pontoon foundered, however.

It should be noted that the PONTON 1's watertight integrity was not established. It is not possible to verify how long this condition had already existed. Fortunately, nobody came to physical harm as a result of the PONTON 1 foundering. If the internal doors had been closed, then only one compartment would have been flooded with water and the PONTON 1 would have remained buoyant. As it was, the inflowing water was able to spread throughout the pontoon and thus reach the maximum surface, so as to finally make her capsize.

6 SAFETY RECOMMENDATIONS

The following safety recommendations do not constitute a presumption of blame or liability.

6.1 Robert Krebs KG GmbH & Co.

The Federal Bureau of Maritime Casualty Investigation recommends that Robert Krebs KG GmbH & Co. encourage its ship's commands to ensure that the watertight integrity of their ships is always established.

6.2 Ship's command of the BÖSCH

The Federal Bureau of Maritime Casualty Investigation recommends that the ship's command of the BÖSCH maintain the watertight integrity of its tow at all times.

7 SOURCES

- Enquiries of the WSP
- Written statements
  - Ship's command
  - Owner
  - Classification society
- Witness accounts
- Opinion of the Institut für Werkstoffkunde und Schweißtechnik Service GmbH (*Institute of Materials Science and Welding Technology*)
- Opinion of the Institute of Ship Design and Ship Safety of the Hamburg-Harburg University of Technology
- Handbuch für Schiffssicherheit (*manual for ship safety*), published by Professor J. Hahne, Seehafen Verlag GmbH, 2006, first edition, ISBN 3-87743-815-6, page 215
- Nautical charts and ship particulars, Federal Maritime and Hydrographic Agency (BSH)
- Radar recordings, ship safety services/vessel traffic services
- Documentation, Ship Safety Division (BG Verkehr)
  - Accident Prevention Regulations (UVV See)
  - Guidelines and codes of practice
  - Ship files