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

Investigation Report 638/06

Serious Marine Casualty

Serious Personal Injury on board MV MAIKE on 30 December 2006 off the Dutch Coast

15 August 2007

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

The present 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 the Investigation Report.

Issued by:
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1 Summary of the Marine Casualty

On 30 December 2006 the dry bulk cargo vessel MAIKE sailing under German flag was on her voyage from Rostock, Germany, to Perth in Scotland. At about 11:25 hours[1], the ship's command ordered two crew members to the forecastle, in order to check a bilge alarm in the bowthruster room. Both of them had put on protective rainwear and hard hats.

At that time the vessel was in the Dutch exclusive economic zone (EEZ) within the Traffic Separation Scheme 'Terschelling German Bight'. In this area, the wind was blowing from southwest with average forces of 7 to 8 Bft and gusts of 9 to 10 Bft. The wave heights were between 3 and 4 m.

The bilge alarm proved to be a false alarm that had been triggered by condensation water. In order to bail the water by means of a bucket, one deck hand remained in the bowthruster room, while the other one on deck received the bucket handed up to him. At about 11:35 h, the seaman standing on deck was hit by a wave coming over the stem, whereby he lost his hard hat. When an even greater wave arose, he sought shelter behind the opened hatch cover, which was secured by means of a retaining hook. Due to the impact of the wave, the retaining device broke, so that the hatch cover closed. Thereby the deck hand's head was jammed between the cover and the hatch coaming, whereby he suffered severe injuries.

The injured seaman was recovered by a rescue helicopter after he had been given First Aid and then transported into the hospital of Groningen, The Netherlands. He survived the accident and returned to Germany one week later for further treatment.

No harmful substances were released by the accident.

[1] All times are stated in Central European Time (CET) = Universal Time Code (UTC) + 1 hour.

2 Scene of the Accident

Nature of the incident:	Serious Marine Causalty
Date/Time:	30 December 2006, 11:35 h
Location:	Dutch EEZ, TSS Terschelling German Bight
Latitude/Longitude:	φ 53°35,2'N λ 005°02'E

Section from Chart 50 INT 1045, BSH

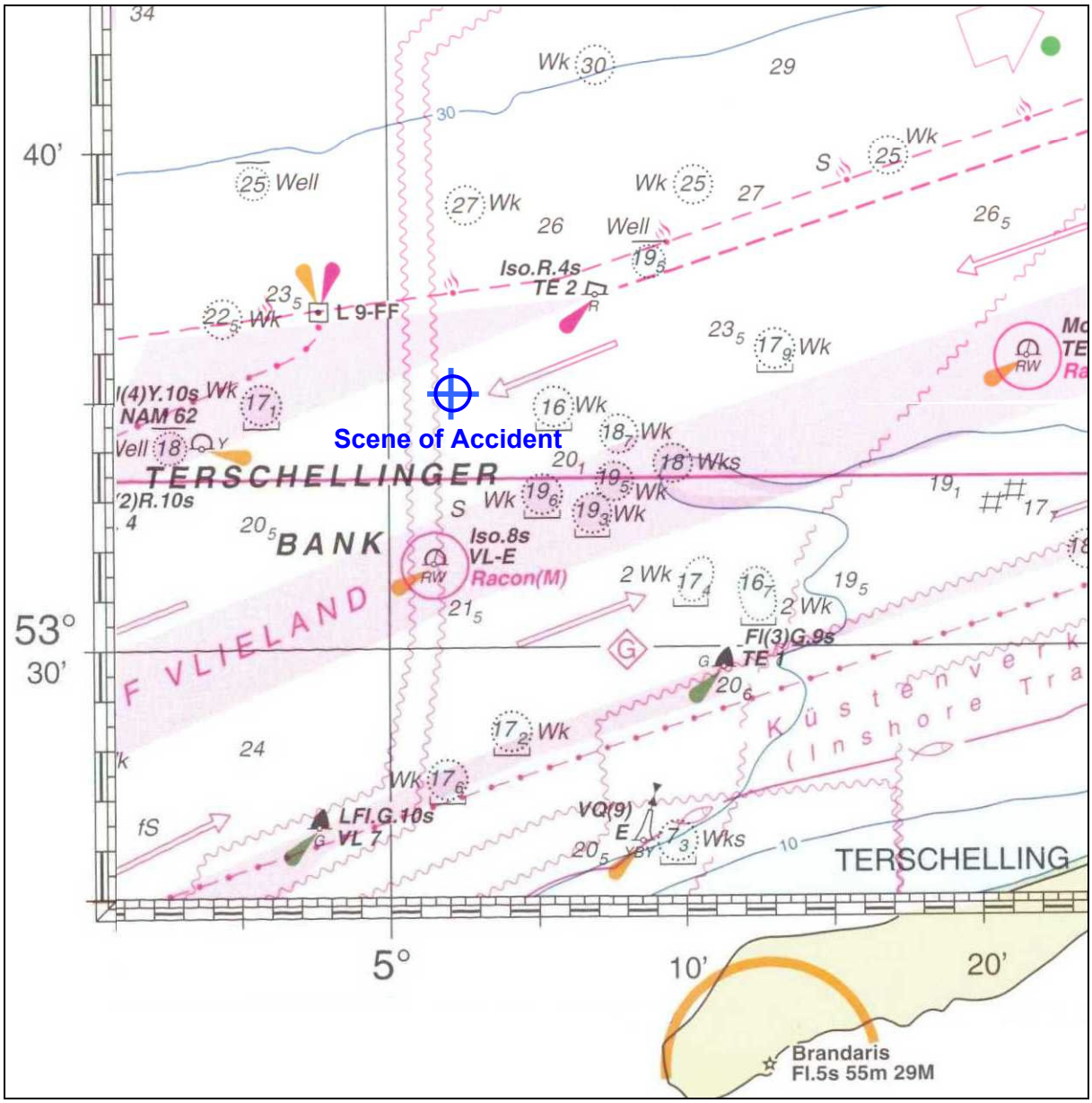

Figure 1: Chart

3 Vessel Particulars

3.1 Photo of MAIKE

Figure 2: Photo of MAIKE

3.2 Particulars of MAIKE

Name of the vessel:	MAIKE
Type of vessel:	Dry bulk cargo vessel
Nationality/flag:	Germany
Port of registry:	Husum
IMO number:	8905115
Call sign:	DJLS
Owner:	Arp, Thordsen, Rautenberg GmbH & Co. KG
Year built:	1989
Shipyard/yard number:	Husumer Schiffswerft Inh. Gebr. Kröger GmbH & Co. KG / 1512
Classification society:	Germanischer Lloyd AG
Length overall:	82.19 m
Breadth overall:	11.30 m
Gross tonnage:	1,599
Deadweight:	1,908 t
Draught at time of accident:	4.0 m
Engine rating:	600 kW
Main engine:	Callesen 4-stroke diesel, 427 FTK-G
Speed:	10 kn
Hull material:	Steel
Number of crew:	5 + 1 passenger

4 Course of the Accident

4.1 Course of the Voyage

On 30 December 2006, the dry bulk cargo vessel MAIKE sailing under German flag and loaded with wheat was on her voyage from Rostock, Germany, to Perth in Scotland. The crew consisted of five seamen, four of German nationality, one Cape Verde deck hand and one female passenger. The ship made speed of 2 to 2.5 kn, when the alarm of the bowthruster room bilge was triggered at about 11:25 h. At that time the vessel was in the Dutch EEZ within the Traffic Separation Scheme ‘Terschelling German Bight' about 3 nm southwest of buoy TE 2.

In this area, the wind was blowing from southwest with average forces of 7 to 8 Bft and gusts of 9 to 10 Bft. The wave heights were between 3 and 4 m, and the current was about 1 kn in eastern direction.

The master reduced the speed of the vessel to a minimum, applying “Dead slow ahead” on the control lever, and turned the vessel into the wind. Then he ordered two crew members to the forecastle, in order to check the alarm. Both of the deck hands wore protective rainwear and hard hats, leaving the chin straps of the safety helmets open. Having arrived on the forecastle, they secured the cover of the hatch leading to the bowthruster room by hooking the cover into a retaining device fixed outside at the hatch.

After they had entered the bowthruster room through the hatch, they stated that the bilge alarm had been triggered by condensation water. Then they started bailing, the Cape Verde seaman handing full buckets upwards and the German seaman receiving them on deck. When towards 11:35 hours about 120 l had been bailed, the seaman standing on deck has hit by a wave coming over the stem. Thereby he lost his hard hat. When an even greater wave arose, he sought shelter behind the hatch cover. However, due do the impact of the wave, the retaining device broke, so that the hatch cover fell down. Thereby, the now bare head of the seaman was jammed between the cover and the hatch coaming.

When the deck hand standing in the bowthruster room saw his jammed colleague, he tried to stem the cover upwards from the inside. However, he did not succeed due to the weight of the hatch cover. Only with the assistance of the injured seaman, who was still responsive, he succeeded in opening the cover. Thus, the injured seaman got free. Despite his serious injuries he was able to move astern over the upper deck by himself and supported by his colleague.

The 1st Nautical Officer, who had been alerted by waving, joined them and helped to bring the injured seaman below deck. While First Aid measures were performed, the ship’s command informed the Dutch SAR unit “Den Helder Rescue”. The SAR unit arrived by helicopter about half an hour later and at first, by two paramedics, took over the care for the injured seaman on board.

Subsequently, the injured was recovered and flown to the hospital of Groningen/The Netherlands.

MAIKE continued her voyage, and entered the port of Perth in Scotland on 3 January 2007. There the British Maritime and Coastguard Agency - MCA performed a Port State Control on board the MAIKE.

On 6 January 2007, the injured seaman was discharged from the Dutch hospital and returned to Germany for aftertreatment.

4.2 Injuries

The casualty suffered severe injuries of his head. In the University Hospital of Groningen, The Netherlands, in particular various fractures of the frontal sinus, of the cheekbones bilaterally and of the nose were treated surgically. In addition, multiple lacerated and partly contused wounds were treated. The multiple fractures of the jaw had resulted in a loss of multiple teeth and were also operated.

Moreover, within the scope of the aftertreatment in Germany significant cerebral compressions were diagnosed, which resulted in the casualties' loss of olfactory sense and consequently of gustatory sense as well. With completion of the investigation, it can not yet be determined to what extent these consequential injuries will be permanent. Three months after the accident, the casualty underwent medical rehabilitation measures.

5 Investigation

The officers of the British MCA went on board a few days after the accident within the scope of the Port State Control. Before, during, and after the control, the co-ordination with the German Federal Bureau of Maritime Casualty Investigation (BSU) investigating the accident was prosperous. Apart from that, the German Federal Police as well conducted their own investigations.

5.1 Port State Control by MCA

After MAIKE called the port of Perth on 3 January 2007, the MCA conducted a Port State Control. Within the scope of this control, an extensive photographic documentation was prepared, relevant ship's documents were consulted, copies were made, and a report was issued. According to this report, MAIKE held all required and valid ship's certificates. In the inspection of the upper deck, two missing and one loose safety bolts on the folding hatch covers were stated, in addition to the broken retaining device for the hatch cover.

The photographs and documents taken and secured by the MCA were transmitted to the BSU.

5.2 Investigation by German Federal Police

In their independent investigation procedure, the German Federal Police, among others, conducted a hearing of witness with the casualty, the results of which were made available to the BSU.

5.3 Investigation by BSU

The BSU surveyed MAIKE after her return from Perth. The broken retaining device of the hatch cover was flame-cut, as agreed with the German Federal Police, and seized by the BSU for further investigation.

5.3.1 Survey of MV MAIKE by BSU

The survey of MAIKE was performed by two staff members of the BSU in Husum, Germany, on 9 January 2007. The forecastle, where the accident had occurred, was thoroughly surveyed in the presence of the owners' representatives and of the crew members of the day of the accident. The access hatch as well as the safety retainer for the cover were measured and documented by photographs. Later, the broken retainer was cut off and seized by the BSU for the purpose of thorough material tests.

The bridge of the vessel was also surveyed, and copies of the required ship's records were made, as far as these had not already been submitted.

5.3.2 Propulsion of MV MAIKE

MAIKE is driven by a 6 cylinder Callesen motor. The nominal power is 600 kW at 500 revolutions per minute (rpm). The bowthruster with a power of 120 kW is supplied

with energy via a shaft-driven generator (electrical power: 75 kVA). The propulsion of the vessel is controlled via a left-hand controllable pitch propeller arranged aft amidships with a nominal rotation speed of 254 min^{-1}. The vessel has a fin rudder with a maximum rudder angle of 45°.

5.3.3 Retaining Devices for Hatch Covers on the Forecastle of MAIKE

On the forecastle of MAIKE, there are a total of four hatches (cf. fig. 3, scene of the accident is marked in red).

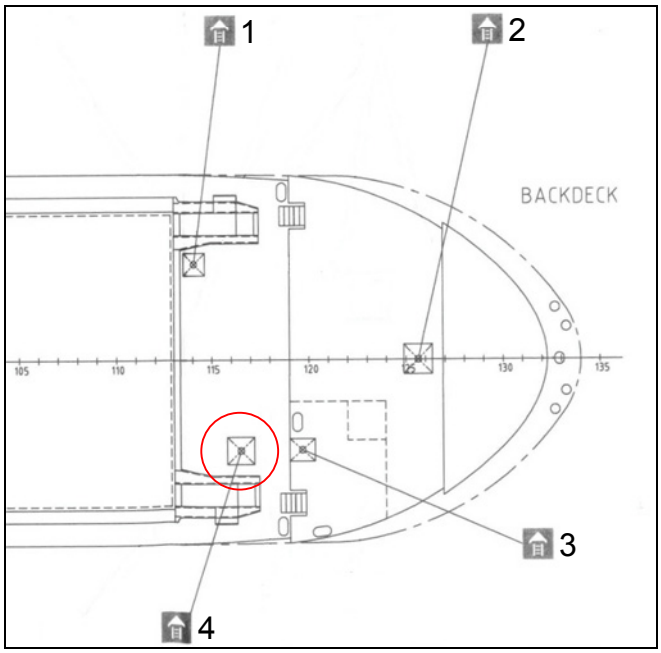

Figure 3: Plan of the forecastle with the four hatches

For each hatch cover, there is one retaining device intended to secure the cover from the outside. The retaining device broken on the day of the accident (No. 4) is identical in construction with the intact device No. 2 (cf. figs. 4 and 5).

Figure 4: Broken device (No 4)

Figure 5: Intact device (No 2)

The edge length of the broken U-profile is 80 x 50 mm with a material thickness of about 8 mm. The total of four retaining devices on the hatch coamings on the forecastle differ in that the retainers of the hatch covers No. 2 and No. 4 are fixed by means of U-profiles mounted on the outside of the hatch coaming, whereas the retainers of the other two hatch covers are fixed by means of round profiles mounted above the hatches (cf. fig. 6).

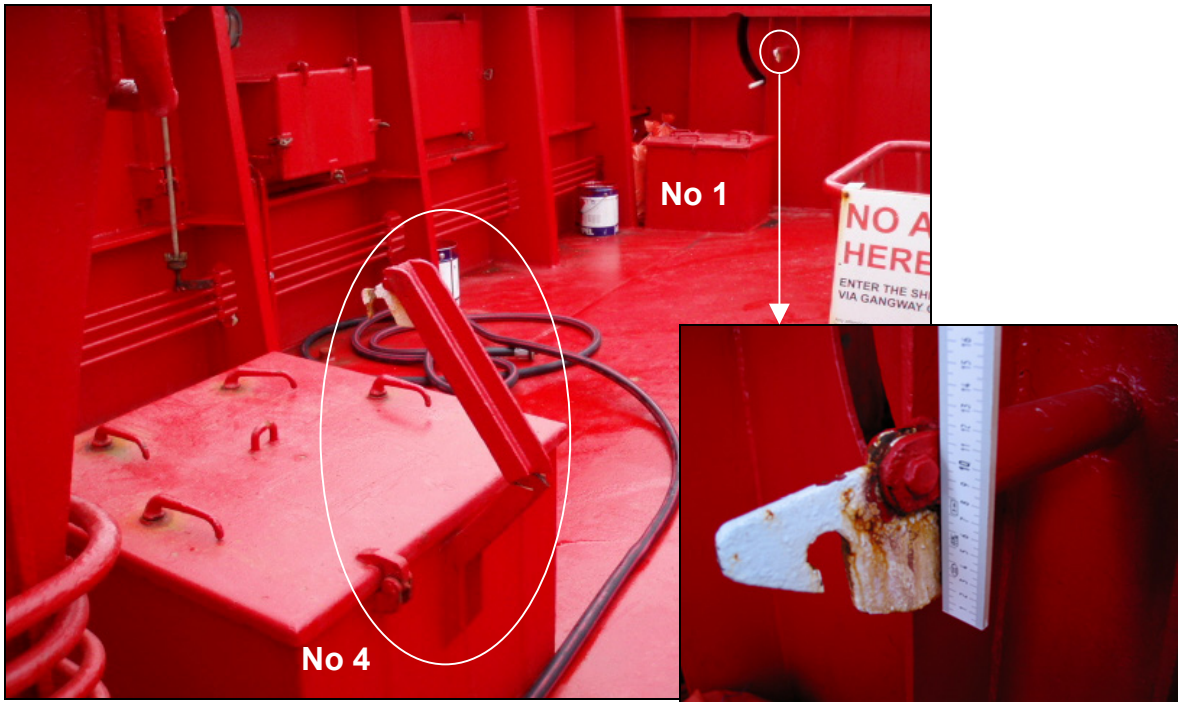

Figure 6: Different retaining devices on the forecastle of MV MAIKE

On the inside, the hatch covers are not provided with any (additional) retaining device.

The cover of the hatch No 4 is made out of steel, like the other hatch covers, and weighs 70 kg. The coaming of the hatch has a height of 640 mm, the cross section of the deck opening is 840 x 840 mm.

5.3.4 Expert Opinion on the Materials

The Institute for Material Science and Welding Technology of the Hamburg University for Applied Sciences (HAW) performed material tests on behalf of BSU on the broken hatch cover retaining device, that achieved the following results:

Due to its design, the retaining device showed a kink. In order to achieve this, the shipyard inserted two wedge-shaped pieces into the U-profile, that had been delivered by the factory in a straight condition, and connected them to the profile by welding seams (cf. fig. 7; wedges marked in red, welding seams in blue).

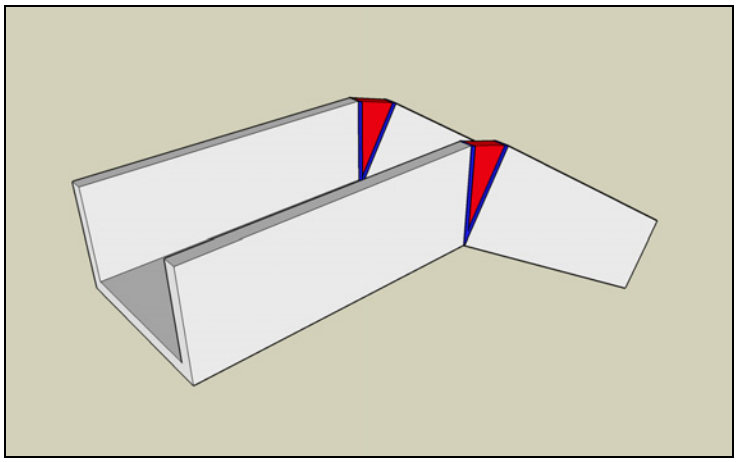

Figure 7: Illustration of the wedges inserted into the U-profile

Both, the U-profile as well as the inserted wedges, were made out of weldable steel S235. On the surfaces of the tear of the U-profile, despite the brisk corrosion that occurred after the accident, separation fractures could be identified on the outer and inner edges. In the centre of the surfaces, traces of a flame cut were present instead of fragmentation (cf. figs. 8 and 9).

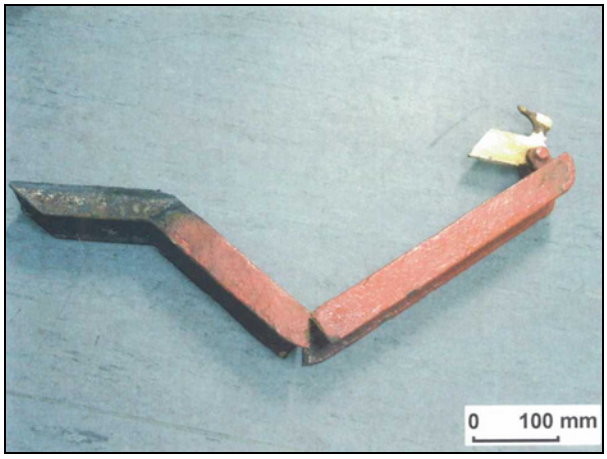

Figure 8: Cot-off retaining device

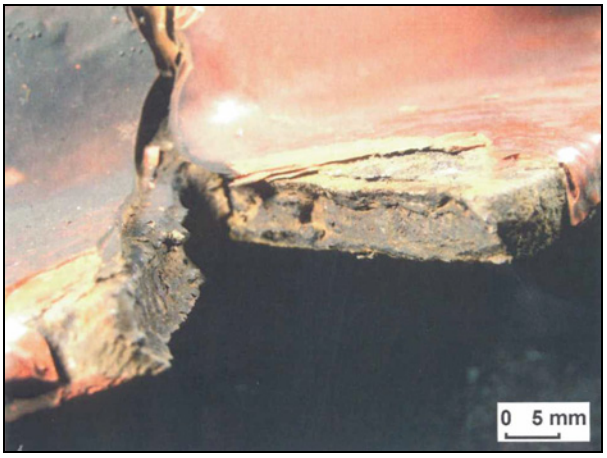

Figure 9: Magnification of the crack surface

As only the area of the edges showed crack structures, the experts reached the conclusion that the material in the centre had not been previously connected by welding seams.

In order to verify that assumption, a material sample was extracted from the crack surface, and a macroscopic section was made (cf. figs. 10 and 11).

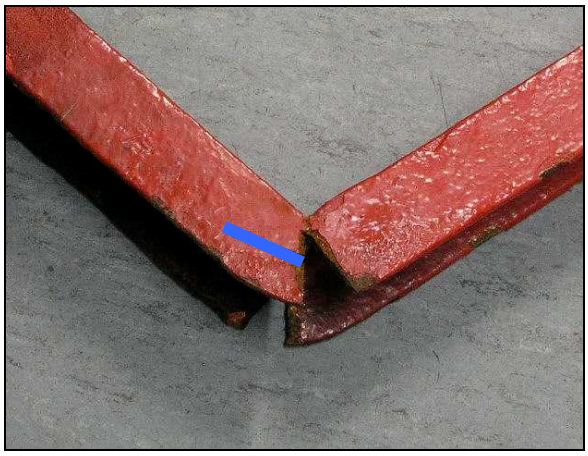

Figure 10: Sampling point

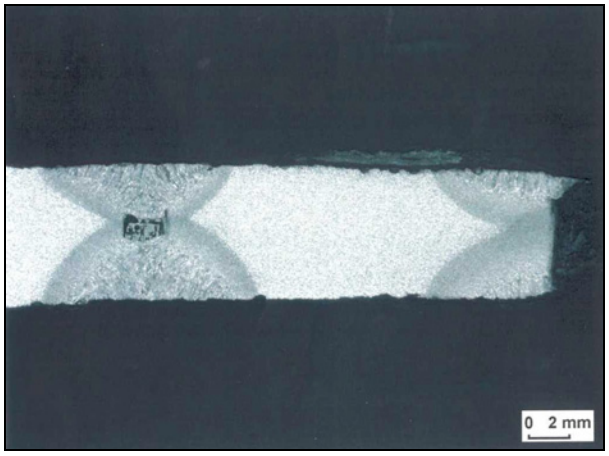

Figure 11: Macroscopic section with 2 welding seams

The macroscopic section shows two of the welding seams for one of the inserted wedges, the right seam of which is cracked. The welding seams consist of two layers each, that were welded transverse to the direction of the strain as so-called butt joints. The raised part of the seam was abraded after welding, so that the welding seams could no longer be identified from the outside.

In the centre of the material, there are two non-welded bars (cf. figs. 12 and 13; non-welded bars marked by red arrows). The one located near the intact seam lacks penetration for a depth of about 2 mm and the one near the torn seam for about 5.5 mm.

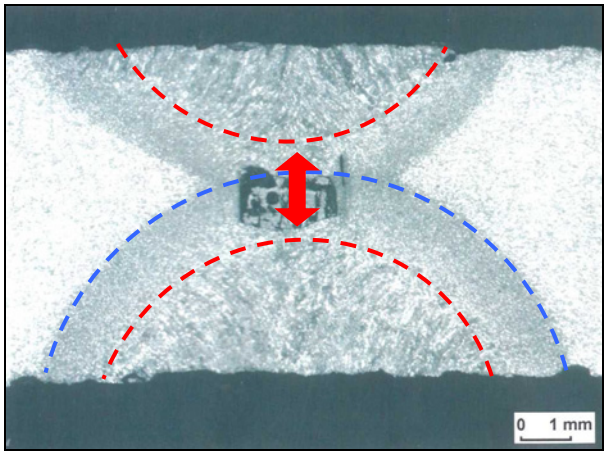

Figure 12: Magnification of the intact seam

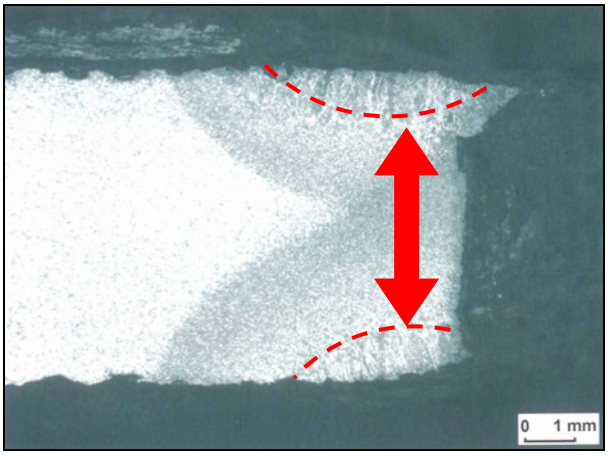

Figure 13: Magnification of the cracked seam

Thus, the welding filler used (cf. red edges; heat affected zones marked in blue) did not completely fill the material. The supporting cross section of the welding seam cracked during the accident had a thickness of about 2.5 mm only. The remaining 5.5 mm of the material were not connected, which is why the structures of the flame cut could still be identified (cf. fig. 9).

Therefore, the material testing came to the conclusion that the hatch cover securing device had cracked due to overload. The expert opinion recommends, for safety reasons, to check the welding seams on comparable safety retainers or to replace them with safety devices welded with full root penetration.

6 Analysis

The structural design of the retaining device as well as the workmanship of the performed welding substantially contributed to the marine accident.

The inappropriate manner in which the subsequent casualty wore his hard hat promoted the occurrence of the severe consequences for his health.

In addition, there are doubts about the necessity of the manual bailing work performed on the exposed forecastle of MAIKE immediately proximate to the accident in the prevailing bad weather conditions.

6.1 Design of the Retaining Device

The designs of the retaining devices for the hatch cover on the forecastle of MAIKE do not meet the approved state of the art. This applies for the retainer broken on the day of the accident as well as for the other three retaining devices mounted on the forecastle of MS MAIKE.

Relevant regulations for the evaluation of hatch design and of retaining device design are the Accident Prevention Regulation for Shipping Enterprises (UVV-See) issued by the See-Berufsgenossenschaft (See-BG), the Rules and Guidelines of the classification society Germanischer Lloyd (GL) as well as the recommendations issued by the DIN Deutsches Institut für Normung e.V. (German Institute for Standardization), in particular DIN 83 404 Part 1[2] and Part 3[3] as well as DIN 83 405[4].

With a value of 640 mm, the height of the coaming of hatch No 4 does meet the requirements of UVV-See (art. 201 para. 2 sentence 2)[5] and the GL Rules and Guidelines (I - Part 1 Chapter 1, Section 17 (hatchways), A.1.2 and D.1.4)[6].

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[2] Small hatches onboard ships – Part 1: Composition of weathertight ship's hatches, safety provisions

[3] Small hatches onboard ships – Part 3: Weathertight covers

[4] Securing devices for hatch covers of small hatches onboard ships

[5] Art. 201 para. 2 sentence 2 UVV-See reads as follows:
'For hatches of a clear cross-section up to 1.00 m x 1.00 m, a coaming height of 0.60 m is sufficient.'

[6] I-1-1 Section 17, A.1.2 of the GL Rules and Guidelines reads as follows:
'Hatchways are to have coamings, the minimum height of which above the deck is to be as follows:
- in position 1: 600 mm
- in position 2: 450 mm.'

I-1-1 Section 17, D.1.4 of the GL Rules and Guidelines reads as follows:
'Companionways or access hatches on exposed parts of freeboard decks, on decks of closed superstructures and in special cases on the deck of deckhouses are to be of solid construction. The height of the doorway sills is to be 600 mm above decks in pos. 1 and 450 mm (hatches) and 380 mm (doors) respectively above decks in pos. 2.'

Note: The classification of the hatches respective of their position results from section 1, H.6.7 of the GL Rules and Guidelines (position 1 = exposed freeboard decks).

The dimensions of deck opening of 840 x 840 mm also meet the requirements of the GL Regulations (I-1-1 Section 17, D.1.6)[7].

Concerning the retaining devices for hatch cover, objectives set by the See-BG and GL provide general requirements for securing hatch covers from closing.

Art. 202 para. 1 and 3 of UVV-See read in parts as follows:

> '(1) Hatchcovers (...) shall have appliances with which they can, in an accident-proof manner, be secured and released in their open position and in the designated partly open positions. (...)
> (3) Steel hatchcovers (...) shall be provided with arrangements to secure them in their set positions.'

I-1-1 Section 17, D.2.6 of the GL Rules and Guidelines provides:

> 'Small hatches on the fore deck are to be fitted with an independent secondary securing device e.g. by means of a sliding bolt, a hasp or a backing bar of slack fit, which is capable of keeping the hatch cover in place, even in the event that the primary securing device[8] became loosened or dislodged.
> (...)
> Fall arresters against accidental closing are to be provided.'

Following these provisions and recommendations, each retaining device used for securing an open hatch cover on a ship's forecastle must ensure that the cover does not shut accidentally.

Since 1976, that is before MAIKE was built, the DIN Recommendation 83405 stipulates a self-locking retainer design for the covers of small hatches following DIN 83404, which establishes the safety standard according to the approved state of the art (form A, cf. fig. 14).

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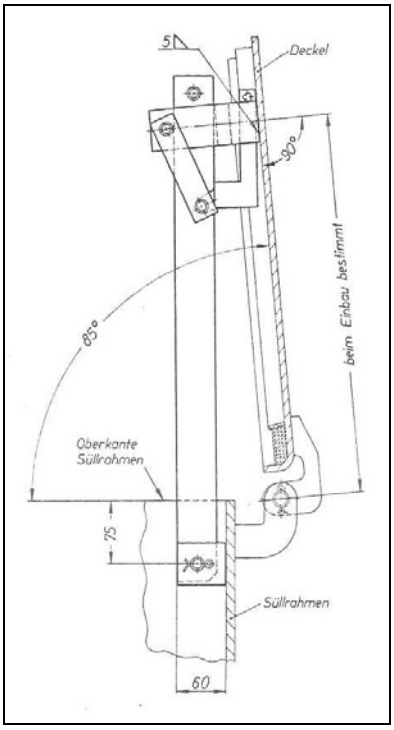
[7] I-1-1 Section 17, D.1.6 of the GL Rules and Guidelines reads as follows:
'Access hatchways shall have a clear width of at least 600 · 600 mm.'

[8] *Note*.: The term 'primary securing device' refers to weathertight devices as described in I-1-1 Section 17, D.2.4 of the GL Rules and Guidelines.



Source: DIN 83405

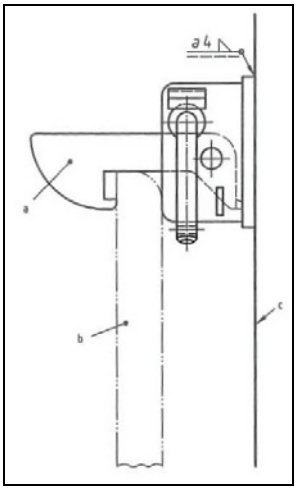
Figure 14: Retaining device form A in conformity with DIN-standards

This retaining device in conformity with DIN-standards is to be mounted onto the inside of the hatch coaming. In the present version of DIN 83405 from 2001, for hatches of comparable size, as a device that secures the hatch cover from the outside only one other form (form C) is determined as an alternative. However, even that alternative device has a design fundamentally differing from the retainers that are mounted on the forecastle of MAIKE.

Both of the design alternatives conforming to DIN-standards lock the backing bars in place automatically. For these solutions, straight steel profiles without kinks are to be used, which in particular in case of form A produce a favourable physical load sharing by numerous bolts inserted in the upper part of the device.

Therefore, the retaining device mounted on the forecastle of MAIKE consisting of a hook picking from outside the hatch, fixed onto a rigid U-profile with multiple kinks, must be considered as non-conforming to DIN-standards. On the contrary, the design's resistance was already weakened by the inserted wedges, regardless of the execution of the welding seams.

According to the present standards, the retaining devices of the hatches No 1 and No 3 on the forecastle of MAIKE do no longer correspond to the technical standards established in DIN 83405 as well. The retainers are similar to the retaining device form D (cf. fig. 15) determined in DIN 83405 since 2001, a not self-locking retaining device also to be mounted above the hatches.



Source: DIN 83405

Figure 15: Retaining device form D in conformity with DIN-standards

However, according to DIN 83405, this type of retainer is only to be provided for hatches with an inside coaming's dimension of more than 1,330 mm, that is, for significantly larger hatches than the one on the forecastle of MAIKE. In addition, such a design requires the hook to directly secure the upper edge of the hatch cover instead of, like on MAIKE, just pick into a lug mounted onto the hatch cover. Over and above, an additional securing clamp is required to be manually put over the hook, in order to prevent any unfastening of the hook.

It must be noted that the design of the retaining devices onboard MAIKE do not meet the technical state of the art provisions given in DIN 83405. The hatch covers with retaining devices installed on the forecastle of MAIKE are not dimensioned as 'wave breakers' for dynamic load. Basically, they only shall enable to go below or on deck. During the numerous surveys on board MAIKE conducted by See-BG and GL, the retaining devices for the hatch covers were never found objectionable. Both consider the devices sufficient for preventing accidental closing of the hatch cover on entering and leaving the hatch. According to their statements, the hatch is strictly to remain closed in case of sea wash. However, in accordance with DIN 83405 the size of the hatch, not its function, is relevant for the choice of the retaining device's form.

Therefore, BSU takes the view that an accident-proof securing of the hatch cover as required by art. 202 para. 1 of the UVV-See has not been installed.

6.2 Workmanlike Welding Performance

The technical workmanship of the welding performed on the hatch cover's retaining device which broke on the day of accident were inappropriate and not state of the art. As can be learned from the expert opinion, the welding seams connecting the inserted wedges with the U-profile were not carried out with full penetration. The steel partly showed significant non-welded bars (5.5 mm compared to a material thickness of only 8 mm).

By grinding the raised part of the seam, the connection between the wedges and the U-profile was additionally reduced. Under these preconditions, the resistance required for a use as safety retainer for the hatch cover was lacking. The wash overload affecting the opened hatch cover finally caused the crack of the welding seams and thus the jamming of the seaman, resulting in severe injuries.

The faultiness of the welding joint could not be recognized from the outside, as it was covered with layers of paint. An accurate workmanlike performance by the shipyard is indispensable, because a rupture of a welding, in particular in case of components that serve for the safety of the crew, can have considerable effect on the lives and health of crew members. The workmanship has to meet the requirements of dynamic load occurring in daily operation of the vessel (e.g. ship's movements) as well as calculable overload (waves coming over the stem).

In case of doubts concerning the connecting strength of materials used, it must be ensured that the material can resist the working loads, e.g. by consultation with the shipyard or random material inspection. A visual check for the formation of incipient cracks should also be performed at regular intervals, independent of any known material deficiencies.

6.3 Way of Using Personal Protective Equipment

The consequences of the accident were aggravated, as the subsequent casualty was wearing his hard hat unsecured. Due to the open chin strap, the helmet could be torn off by the first wave coming over the stem, leaving the seaman's head without protection when hit by the hatch cover.

In its report on the fatal maritime casualty on board MS AUTO ATLAS (file number 350/03), the BSU had already called the attention to the necessity of appropriately putting on protective wear, in particular the chin straps of safety helmets.

6.4 Necessity of Working on Deck

The fact that the triggered bilge alarm quickly proved to be a false alarm due to condensation water provokes doubt concerning the necessity to have the two deck hands performing work on the exposed forecastle for a longer period than necessary in the prevailing bad weather conditions.

Thus, a bilge pump could have been used for bailing the condensation water, instead of bailing the significant quantity of water manually and time-consuming by use of a bucket. Considering the prevailing wind and seastate conditions, the deck hands' stay on the forecastle could have been shortened by such a measure.

Although the ship's command had already performed measures of good seamanship by reducing the vessel's speed and heaving it to the wind, it could not prevent the seaman working on the forecastle from being hit and seriously injured by two strong waves coming over the stem. Therefore, the work of crew members on deck during heavy weather should generally be limited to indispensable activities to be carried out in the shortest time span possible.

This particularly applies, if the working area does not provide an appropriate possibility to seek shelter in heavy weather. The use of open hatch covers as wave-breakers is to be considered generally inappropriate.

7 Safety Recommendations

The following safety recommendations shall not create a presumption of blame or liability, neither by form, number nor order.

The Federal Bureau of Maritime Casualty Investigation recommends **owners and operators of seagoing vessels as well as shipyards** to meet the approved technical state of the art in planning and designing safety relevant components on seagoing vessels. This particularly applies in case the relevant regulations of the See-Berufsgenossenschaft and of the classification society allow a choice of design.

The Federal Bureau of Maritime Casualty Investigation recommends the **See-Berufsgenossenschaft and the classification societies** to allude to determined deviations from DIN-standards in design, and as the case may be document those as equivalent state of the art.

The Federal Bureau of Maritime Casualty Investigation recommends **owners and operators of seagoing vessels as well as shipyards** to ensure and periodically inspect, that metallic components that serve safety aspects on board seagoing vessels are sufficiently connected by joint welding, in order to withstand overloads and to prevent incipient cracks due to dynamic operational strains. Workmanship is to be performed in an appropriate manner, meeting the design requirements in vessel operation.

The Federal Bureau of Maritime Casualty Investigation recommends **operators of seagoing vessels and ship's commands** to strive for the appropriate use of personal protective equipment.

The Federal Bureau of Maritime Casualty Investigation recommends **operators of seagoing vessels and ship's commands** to work towards limiting the work of crew members on deck during heavy weather to strictly indispensable actions to be taken within the shortest time span possible.

8 Sources

- Witness statements and correspondence:
  - Statement of facts by the Captain
  - Declaration of the case of emergency by the shipping company
  - Accident notification the shipping company
  - Witness statement by the casualty
  - Witness statement by the Cape Verde deck hand
  - Examination report by the University Hospital of Groningen
- Diplomas, certificates, plans and certifications:
  - Abstract from the bridge log
  - Ship's crew list
  - Minimum Safe Manning documents
  - Voyage permit
  - Survey reports by the See-BG
  - Fire protection and safety plan
- Expert opinion on the materials by the Institute for Material Sciences and Welding Technology, Hamburg
- Port State Control report and photo documentation by the MCA
- Expert opinion on the weather conditions by Germany's National Meteorological Service
- ECDIS records on board MAIKE
- Photo documentation of the BSU

The use of the illustrations from DIN 83405 (figs. 14 and 15) by courtesy of the DIN Deutsches Institut für Normung e.V., Department for the standardization of naval and marine engineering, Hamburg.