Bundesstelle for Seeunfalluntersuchung
Federal Bureau of Maritime Casualty Investigation
Bundesoberbehörde im Geschäftsbereich des Bundesministeriums
für Verkehr, Bau- and Wohnungswesen

Investigation Report 262/03

1 April 2004

Serious Marine Casualty:

Rupture of the towing line during towing between VOC FRONTIER and the Tug AXEL on 1 September 2003 in the port of Lübeck

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1 Summary of the marine casualty

On 1 September 2003 at 21.32 h VOC FRONTIER cast off from berth No. 6a in the Vorwerker Hafen in Lübeck with pilot advice with a forward and aft tug. The forward tug connection of the tug AXEL broke as it was crossing from port to starboard, while the tug MICHAEL made fast aft was assisting in the sternway of VOC FRONTIER. The rupture of the tow line caused injuries to three Indian crew members on the forecastle of VOC FRONTIER, two of whom had to be treated as in-patients in hospital. The rupture of the tow connection is attributable to the failure of the Fairlead shackle between the forerunner and tow wire. The transverse forces necessary to break the shackle could only occur because a fairlead shackle without a roller was used.

2 Scene of the accident

Section from Sea Chart 3004, BSH

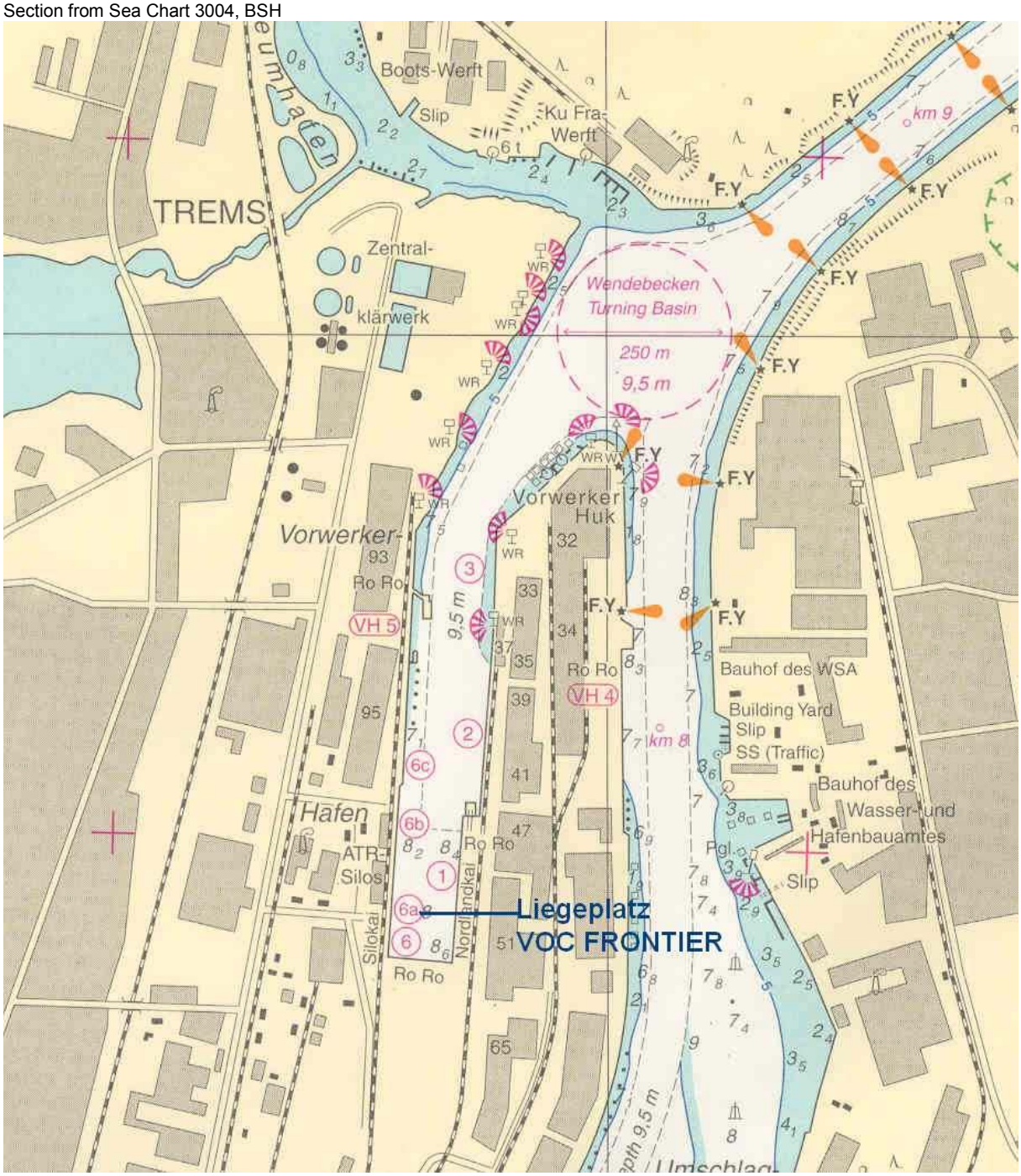

Figure 1: Berth of VOC FRONTIER

3 Vessel particulars and photos

3.1 Vessel particulars VOC FRONTIER

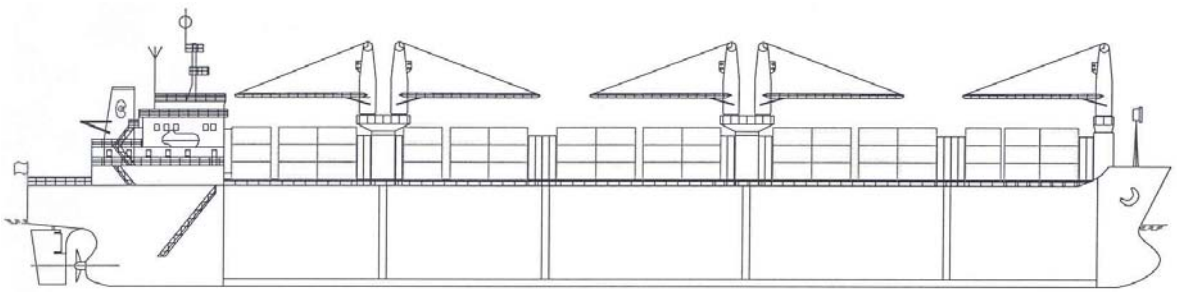

Figure 2: Sketch of VOC FRONTIER

Name of vessel:	VOC FRONTIER
Operator:	Dockendale Shipping
Port of registry:	Nassau
Nationality/Flag:	Bahamas
IMO Number:	9117612
Ship's call sign:	C6YU
Type of vessel:	Cargo vessel
Crew:	22
Classification:	American Bureau of Shipping
Class:	+ A1 (e)
Year built:	1996
Length over all:	181.0 m
Width over all:	26.0 m
Max. draft:	8.6 m
Gross tonnage:	19.354
Deadweight:	29.538 t
Main engine:	Dalian B+W 5S50 MC
Engine rating:	6400 kW
Speed:	14.0 kn

3.2 Vessel particulars AXEL

Figure 3: Tug AXEL

Name of vessel:	AXEL
Operator:	J. Johannsen & Sohn, Lübeck
Port of registry:	Lübeck
Nationality/Flag:	Deutschland
IMO Number:	8918590
Ship's call sign:	DMGZ
Type of vessel:	Tug
Crew:	3
Classification:	Germanischer Lloyd
Class:	100 A5 E1
Year built:	1990
Yard:	J. G. Hitzler Schiffswerft
Length over all:	29,80 m
Width over all:	9,50 m
Max draft:	4,20 m
Gross tonnage:	305
Main engine:	Deutz 628
Engine rating:	2.580 kW
Speed:	12 kn
Bollard pull:	410 kN (41 t)

4 Course of the voyage/course of the accident

On 1 September 2003 VOC FRONTIER cast off from berth No. 6a in the Vorwerker Hafen in Lübeck to go to sea at 21.32 h. The vessel was fast on its starboard side with a northeasterly wind of force 5 bft. At the time of the cast-off manoeuvre the Master, the second mate and the helmsman as well as two pilots were on the bridge of the vessel.

At 21.18 h work was commenced on shortening the mooring lines forward and aft to one fore and stern line each and one fore and aft spring. The Tug MICHAEL made fast aft at 21.25 h. The stern line was cast loose at 21.26 h. At 21.27 h the forward Tug AXEL was fast. The fore line was cast loose at 21.28 h, then at 21.29 h the aft spring and at 21.31 h the fore spring. According to the information supplied by the pilots, VOC FRONTIER had moved approx. 200 m astern at slow speed when the forward tow line broke at 21.35 h.

Directly before this incident the forward tug was at the port bow of the vessel. At the instruction of the pilot the tug changed to the starboard bow. This was to initiate a turning manoeuvre of the vessel. Then there was a loud bang. The forward tow connection broke and injured three Indian seamen working on the forecastle of VOC FRONTIER.

After the accident VOC FRONTIER tied up again at berth 3 of the Vorwerker Hafen at 21.55 h. Directly after this two physicians came on board via the pilot ladder and a little later the River Police Travemünde boarded the vessel.

One crew member sustained skin abrasion on his head and concussion as a result of the accident, the second sustained shoulder and back fractures. These injuries were treated at the University Clinic in Lübeck where the patients remained. The third seaman sustained minor injuries and could be treated on board.

VOC FRONTIER continued her voyage to Rostock at 23.30 h.

5 Investigation

According to the statement by the Master of AXEL, the tow connection consisted of a 5 to 6 m long forerunner (diameter 9“, T-Flex) and a 45 m long wire line (diameter 28 mm, 6-strand * 36 wire with core, see Fig. 4). The eye of the wire was secured to the bolt of the fairlead shackle, the forerunner to the other end of the shackle and the tow hook. The Master was on the bridge, while the crew members stood on the port and starboard side on the superstructure. During casting off the tug pulled crossways to port, whereby the tug was already at the opposite quay with its stem. Then the tug was to pull to starboard and since there was not much space ahead, a little slack came into the tow line. At the same time VOC FRONTIER was proceeding well astern and the tow line soon reached its full length. After a bang a bolt flew in the

direction of the starboard side a the aft edge of the control console of the winches (see Fig. 5). The tow connections broke because the fairlead shackle failed. Damage was sustained to the self winding device of the tow wire, the bunker connection, and the door of the halone trigger station. The forerunner was lying in front of the tow hook and according to the statement by the Master of AXEL the tow wire was hanging loose in the water midships from the middle hawse from the forecastle of VOC FRONTIER.

There were no injuries on the tug. The crew was unable to make any statements about the direction of flight of the broken shackle and the tow wire. The shackle is a licensed 90M shackle. The shackle has a workload of 35 t. The proof load is 55 t and the rupture load 90 t (see Fig. 6). The tug has a bollard pull of 41 t. According to the information supplied orally, the tow lines have a rupture load of approx. 90 t. The possibility that the shackles were subjected to stress beyond the normal workload cannot be ruled out. A comparison with the shackle now installed shows a workload of 35 t. A 120M shackle is installed on the Tug MICHAEL that has a workload of 40 t. Only the bolt of the damaged shackle could be secured. The other parts went over board (see Fig. 7). The steel nose that sheared off and deformations are evident on the bolt.

During towing the fairlead shackle is located free-moving behind the two A-frames of the tug (see Fig. 8). The tow connection is not examined during class renewals. Only the insurer imposes conditions about the nature of the tow connection. The tug crew could not explain why three crew members were injured when the tow connection broke. They do not consider it possible that a 35 m long tow line can fly back up to the forecastle of VOC FRONTIER. In their opinion it was an unfortunate reflex action that led to the injuries.

No statements from the injured crew members could be obtained following enquiries made by the BSU of the agent and owner of VOC FRONTIER.

The BSU commissioned the “Institut für Werkstoffkunde und Schweisstechnik” (Institute for Material Science and Welding Engineering) in Hamburg (IWS) to ascertain the cause of the failure of the fairlead shackle. In the course of a preliminary talk between the BSU and the IWS the question arose as to whether the shackle was really attached in the way claimed by the Master of AXEL, since judging by the direction of flight, the bolt should have flown away and not the other part of the shackle. It is also to be doubted whether a roller led over the bolt. There were no traces of any roller secured to the bolt. Trace marks could be seen that could have originated from a synthetic line too. Both noses of the bolt were bent outwards, one nose was broken off. It was to be examined whether this was a tested shackle and what the cause of the fracture could have been. In any case the shackle was subjected to a transverse force.

5.1 Testing of the bolt

The rope design of the wire rope was stated as 6 x 36 (number of strands and number of wires per strand). From these data it can be derived that this was a rope in accordance with DIN 3064 Warrington Seale with a minimum rupture strength of 458 kN (46.6 t) at a nominal strength of 1770 N/mm².

The fairlead shackle is not standardised so that no statements can be made about the shackle.

The bolt supplied had a diameter of approx. 69 mm and was approx. 122 mm long (Fig. 9). A securing strap was bolted on one side and this was bent during the accident. There had been a securing strap casting on the opposite side that had sheared off. The sheared-off area was approx. 8 x 48 mm.

The bolt is evidently a steel casting and largely non-machined on the surface. The casting skin and mould partition can still be seen. The bolt shows various traces of use. On the one hand there are traces of a wire rope twisted in cross-lay visible on the bolt surface as score marks on the circumference. Next to these score marks traces of a synthetic fibre rope can be seen on a part of the surface, characterised by smoothening of the casting structure. Under examination with a magnifying glass traces of abrasion of a dark grey material evidently used as a protection for the synthetic rope were found on the smooth surfaces. The traces of abrasion on the shackle show that the fairlead shackle was used on the bolt without a roller. The traces of the synthetic rope further show that the rope was arranged on one side round the bow of the shackle and not in the middle.

A hardness test was carried out on the bolt. A hardness of 209 HV 50 was determined from the average of three measurements. According to DIN 50150 a tensile strength of approx. 660 N/mm² can be derived from this. Since the shear strength of the steels can be estimated at approx. 80% of the tensile strength, this results in a shearing force for shearing off the safety strap of approx. 185 kN (approx. 18 t). If one further assumes that the rope was wound at the side of the strap, it can be estimated that the transverse force necessary to shear off can occur at a tensile force of approx. 600 kN. It is only possible to determine this tensile force very roughly since the geometry of the shackle bow is not known and would have to be estimated.

5.1.1 Results of the testing

The forces needed for the shackle to fail could only develop because a fairlead shackle without a roller was used. If a roller had been used, the rope would have been guided in the roller in such a way that no transverse forces of any notable extent could have occurred. The necessary forces lie well above the bollard pull of the tug. In other words they could only occur as a result of a shock-type load.

It must therefore be assumed that slack had developed in the line between the tug and the cargo vessel and that the line was tightened again by a tug manoeuvre. The sudden load occurring as a result then led to failure.

It should be examined whether a longer tow forerunner could have reduced the impact and prevented the failure.

6 Analysis

According to the investigations of the BSU one eye of the tow forerunner was secured to the bolt of the fairlead shackle and one eye of the tow wire to the other end of the shackle. The bolt had no roller according to the expert opinion of the “Institut für Werkstoffkunde und Schweisstechnik” (Institute for Material Science and Welding Engineering). Consequently the transverse force of a shock-type load of approx. 600 kN (60 t) was sufficient to bring the fairlead shackle to break.

According to the statement by the Master ("The wire soon reached its full length, whereby the fairlead shackle broke and banged on the deck"), it is to be assumed that the shackle was exposed to a shock-type stress and that the tow forerunner did not have much stretch reserve anymore.

The examination and survey of the towing gear on tugs is regulated in the classification and building regulations of Germanischer Lloyd (GL). According to this all exchangeable individual parts that are exposed to towing force (or parts thereof) are to be tested with test force by the manufacturer. This load test is to be documented with GL test certificates. It is not specified what a tow connection must look like and whether it is to be surveyed by GL. The operational safety of tow hooks and slip devices is to be tested by the Master at least once a month. Tow hooks with mechanical or pneumatic slip devices are to be removed every two-and-a-half years after the first test on board and be subjected to thorough examination with the test force PL (here 1000 kN) at a recognised test facility. Only insurers impose any conditions regarding the equipment of the tow connection. Maintenance and service are at the discretion of the vessel operator and Master.

According to the information supplied by the Master and operator, certificated material was used for the tow connection (see Fig. 10). According to a purchase voucher of 5 August 1998 the broken fairlead shackle was a shackle with the designation 90M SEL-1071 GL. However, no GL certificate (LA3) for the load test could be submitted. This type of shackle had a stated workload of 30 t, whereby the

tensile strength of the bolt determined in the expert opinion was approx. 660 N/mm² (66 t). A 120M fairlead shackle with roller like that fitted on the tug MICHAEL with a stated workload of 40 t would without any doubt have provided more safety.

In a comment by the vessel operator of 8 January 2004, which is also based on the statement by the Master, it is said that only fairlead shackles with roller are used on the tug AXEL.

It could not be ascertained with certainty whether this was a tested 90M SEL-1071 GL fairlead shackle. With regard to the expert opinion it is to be taken into account that only the bolt and not all parts of the shackle could be tested. However, the test results of the laboratory inspection could only lead to the conclusion (see Fig. 9 trace marks and bending of the bolt) that there was no roller in this case. It is possible that the shackle bow was damaged and no longer complied with the stated loads. However, this would only have promoted the fracture of the shackle. The transverse forces necessary to break the shackle could only occur because a fairlead shackle without a roller was used.

7 Recommendations

The owners, operators and masters of the tug must ensure that test certificates on individual parts of the tow connection are kept in storage and that the material used corresponds to the recognised test standards.

The testing of tow connections should be conducted like the tests to be carried out monthly by the master and crew concerning the operational reliability of and any damage to the towing gear including tow hook and slip connection and the results should be documented. The principles applying by analogy with the Accident Prevention Regulations Sea (UVV See) for handling equipment and other lifting gear and the leaflet F 1 for masters and crews of tugs in towing operations issued by the ship safety authority See-Berufsgenossenschaft should be observed.

8 Sources

The investigation report refers to the investigations by the River Police Lübeck-Travemünde, an expert opinion by the "Institut für Werkstoffkunde and Schweisstechnik" (Institute for Material Science and Welding Engineering) Hamburg, findings and interviews, as well as a survey on board the Tug AXEL by the Federal Bureau of Maritime Casualty Investigation (BSU).

Other institutions involve in the investigation are the BSH, GL, and Messrs. Seil Hering in Hamburg.

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The BSU's investigation reports can be downloaded from the Internet page **www.bsu-bund.de**.

Figure 4: Towing gear AXEL

Figure 5: Control console, Towing winch

	No.90M	No.120M
Forerunner	7'' - 9''	9'' - 11''
Breaking Load	90m/Tonnes	120m/Tonnes
Proof Load	55m/Tonnes	70m/Tonnes
Safe Workload	30m/Tonnes	40m/Tonnes
Weight	7.8 Kilos (17.2 lbs)	13, 3 Kilos (29 lbs)

Figure 6: Mandal Fairlead-Shackle 90M, 120M

Figure 7: Fairlead-Shackle 90M new with damaged bolt

Figure 8: Aft part of Tug AXEL with A-Frames

Figure 9: Shackle bolt, Tug AXEL

Figure 10: Certified fairlead shackle, Tug AXEL