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

Investigation Report 215/10

Less Serious Marine Casualty

Accident involving the shipboard crane on board the wind turbine installation vessel WIND LIFT 1 on 23 May 2010 at the 'BARD Offshore 1' wind farm about 50 nm north-west of Borkum

1 June 2011

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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Table of Contents

Table of Figures

1 Summary of the marine casualty

At 1233[1] on 23 May 2010, an accident involving the shipboard heavy crane occurred on the WIND LIFT 1, an installation vessel for offshore wind turbines, in the offshore wind farm 'BARD 1' about 50 nm north-west of Borkum. The vessel was flying the flag of Germany. The vessel had elevated herself from the water independently by lowering four legs and in so doing had become a working platform connected with the seabed (so-called self elevating unit). Using the heavy crane, an iron pipe (so-called 'pile') of 85 metres in length weighing 425 tonnes and with a diameter of about 3.5 metres was to be lowered into the water in a vertical position, where together with two other pipes of the same dimension and with about half of it driven into the seabed, it was to be used as the foundation of a wind turbine. In executing this task, the upper end of pipe, which was lying alongside, was grasped by the heavy crane by means of a hydraulic grab and raised on one side. At an elevation angle of about 35 degrees and a height of about 40 metres, the pipe suddenly slipped out of the grab and fell with great force back onto the deck of the vessel. Three people on deck were slightly injured while trying to move to safety and/or falling due to vibration. The superstructure sustained heavy material damage. The pile's direction of fall and the fact that at midday there were only a few people on deck prevented the consequences from being more severe.

[1] All times shown in this report are local = CEST = UTC + 2 hours.

2 SHIP PARTICULARS

2.1 Photo

Figure 1: Photo

2.2 Vessel particulars

Name of vessel:	WIND LIFT 1
Type of vessel:	Wind turbine installation vessel
Nationality/flag:	Germany
Port of registry:	Cuxhaven
IMO number:	9516686
Call sign:	DFIC
Owner:	Wulf Seetransporte GmbH & Co. KG
Year built (keel laying/handover):	2007/2010
Shipyard/yard number:	Western Shipyard Klaipeda/34
Classification society:	Germanischer Lloyd (GL)
Length overall:	103.80 m
Breadth overall:	36.00 m
Gross tonnage:	7,650
Deadweight:	2,623 t
Draught (max.):	3.5 m
Propulsion/engine rating:	4 pivoting rudder propellers/1,100 kW
(Service) speed (max.):	10.1 kts
Hull material:	Steel
Hull design:	Self-propelled lifting platform

Minimum safe manning/special personnel:	12/38 (max.)

2.3 Voyage particulars

Port of departure:	Emden
Port of call:	Emden
Type of voyage:	Merchant shipping/national[2]
Manning (including special personnel):	40
Draught at time of accident:	Stationary use as a working platform (standing on the seabed)
Pilot on board:	No

[2] The scene of the accident was located outside of German territorial sea in the German Exclusive Economic Zone (EEZ). The operating condition of the WIND LIFT 1 was 'working platform'. To that extent, definition of whether the installation vessel was on a national or international deployment at the time of the accident and whether it was a 'sea-going ship underway' at all in the legal sense was problematic (see sub-para. 4.1 et seq. below).

2.4 Marine casualty or incident information

Type of marine casualty:	Less serious marine casualty Occupational accident on deck
Date, time:	23/05/2010, 1233
Location:	50 nm north-west of Borkum
Latitude/Longitude:	φ 54°20.4'N λ 005°59.2'E
Ship operation and voyage segment:	Stationary use as a working platform
Place on board:	Upper deck
Consequences:	Three minor injuries, material damage

Excerpt from Nautical chart 50 (INT 1045), BSH[3]

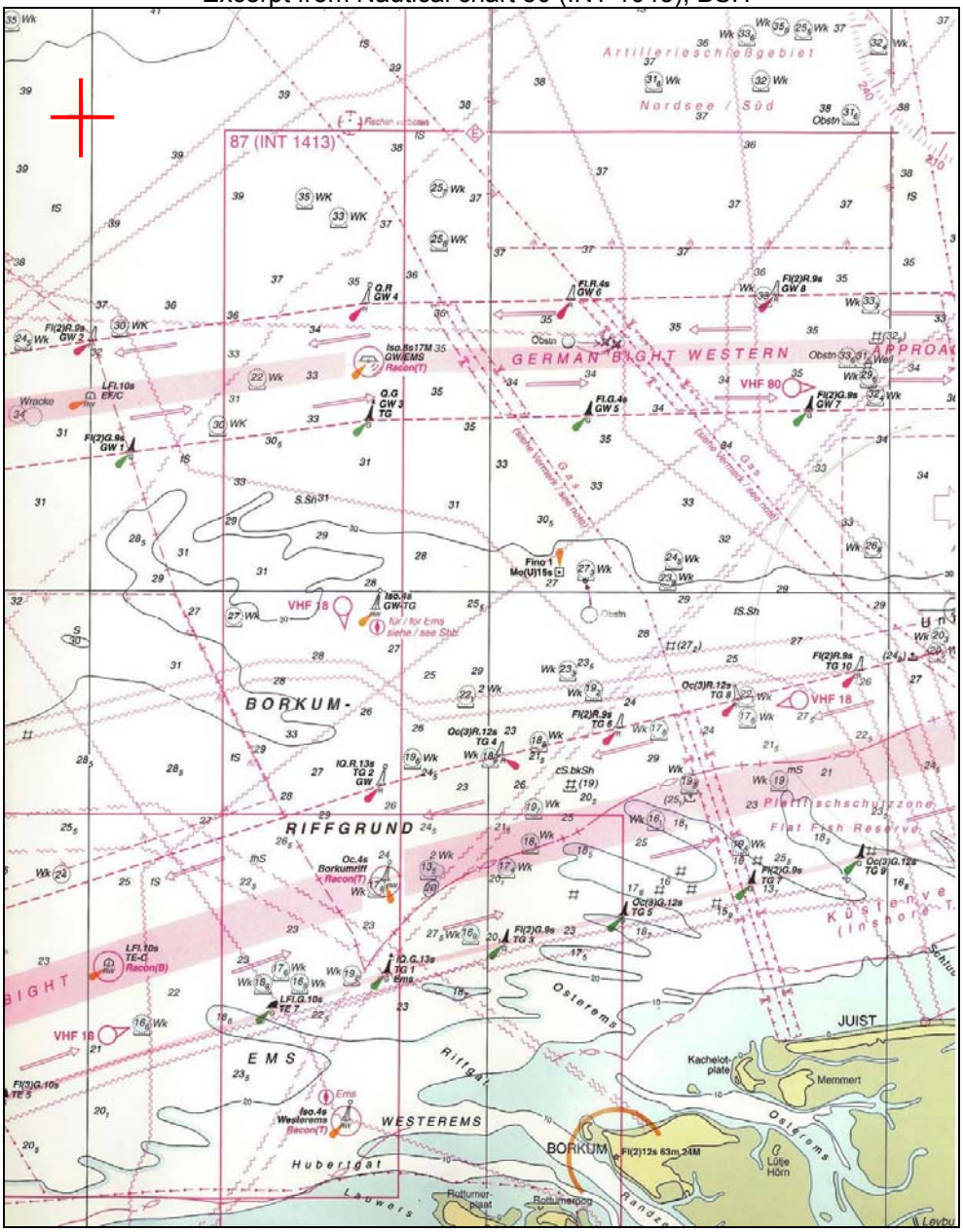

Figure 2: Nautical chart

[3] BSH = Federal Maritime and Hydrographic Agency

2.5 Shore authority involvement and emergency response

Agencies involved:	Internal crisis management by the ship's command, owner and the Bard Group[4]; no involvement of the police or authorities initially
Resources used:	Tug TOW 3
Actions taken:	First aid measures in the shipboard hospital, stability of the platform checked, damage assessment, floatation of the platform, towed to Emden
Results achieved:	WIND LIFT 1 successfully taken to repair yard (SIAG Nordseewerke GmbH, Emden)

[4] Bard Group = A group of companies involved in the installation and operation of offshore wind farms and actual operator of the WIND LIFT 1.

3 COURSE OF THE ACCIDENT AND INVESTIGATION

3.1 Course of the accident

The WIND LIFT 1 was standing on her four extended legs and was in stationary use as a working platform on the day of the accident. At about 1233, one side of an 85 metre pile weighing 425 t (driven vertically into the seabed and used as the foundation of a wind turbine with two other piles of the same dimension), which was horizontally stored alongside on the starboard side of the upper deck, was being lifted with the shipboard crane. In the process, it slipped out of the hydraulic grab and fell out of control back onto the deck. The inclination of the pipe was 35 degrees and the grab was grasping into its upper side. This led to considerable material damage to the upper deck (see **Figs. 5 to 9** below). Several people fell to the ground due to the vessel vibrating, but suffered only slight bruises and grazes on their hands. One person had the presence of mind to throw himself to the ground and in so doing avoided a piece of iron that broke off the pipe due to the force of the impact. This piece of iron flew over the worker, hit the edge of a fairlead and caused part of it to break off (see **Fig. 6)**, after which it was propelled overboard.

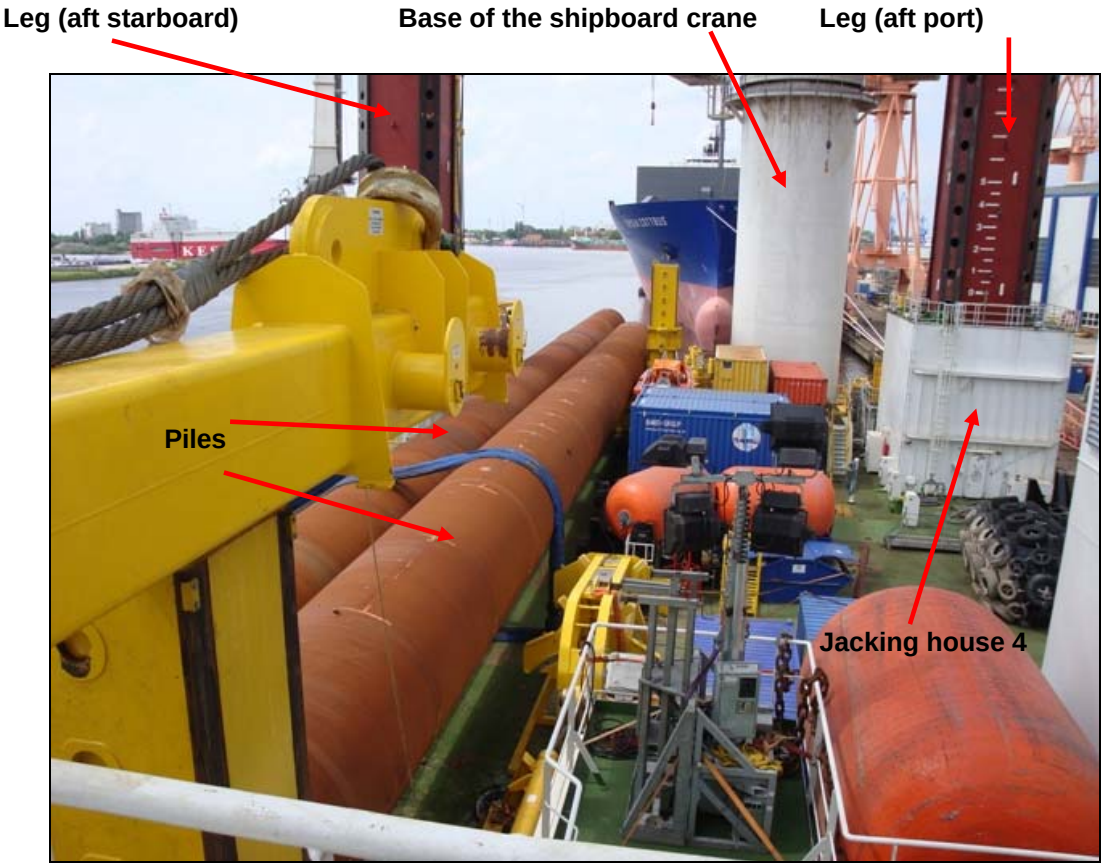

Figure 3: Main deck of the WIND LIFT 1 (1)[5]

[5] Shot from the aft edge of the bridge deck alongside to aft.

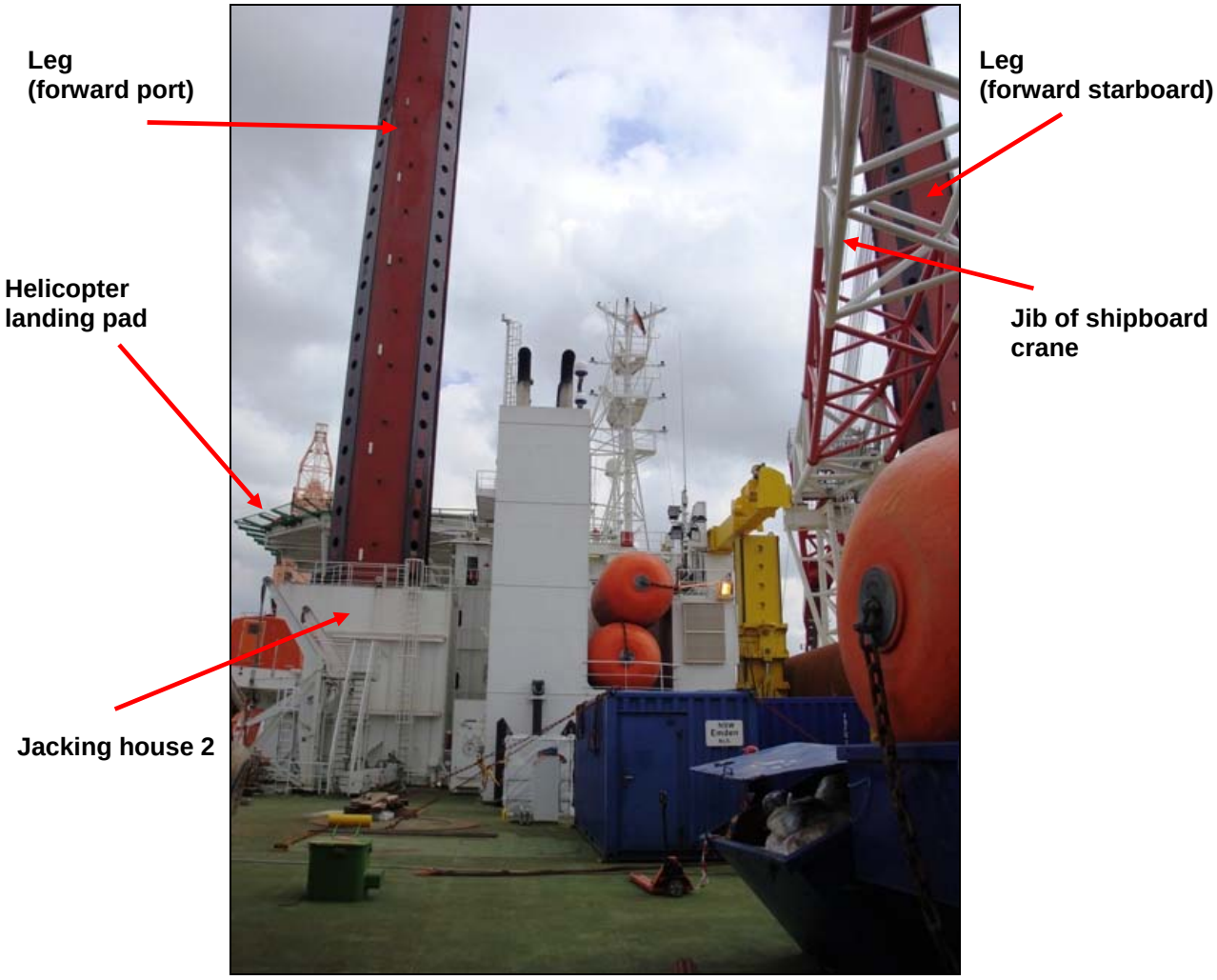

Figure 4: Main deck of the WIND LIFT 1 (2)[6]

A general alarm was sounded immediately after the incident and the presence of all persons on board checked. The injured persons were treated in the shipboard hospital. The master prohibited any further work from being carried out on board and cordoned off the upper deck. The stability of the platform was checked. The master and the 2nd officer on watch inspected the upper deck. The remaining areas of the vessel were inspected by the chief engineer and other technical personnel. Following that, a safety briefing was held on board and the owner and the operator of the WIND LIFT 1 were informed. After the pile was provisionally secured using the crane, which had been returned to operation, and any loose items on deck were secured, the platform was changed to the floating operating condition following internal discussions between the ship's command, owner, and operator and then towed to Emden in the afternoon.

[6] Shot from the deck looking forward.

3.2 Consequences of the accident

3.2.1 Personal injuries

Three people on deck were slightly injured while trying to move to safety and/or falling due to vibration.

3.2.2 Material damage

In the area of the upper deck, it was mainly jacking house 1[7] that was damaged due to a glancing blow by the pile as it fell. There was also superficial damage to various loose and fixed items of equipment and components in the area of impact. In addition, the violent shaking of the platform caused damage to various navigation lights and other minor technical problems. Contrary to initial concerns, there was no structural damage.

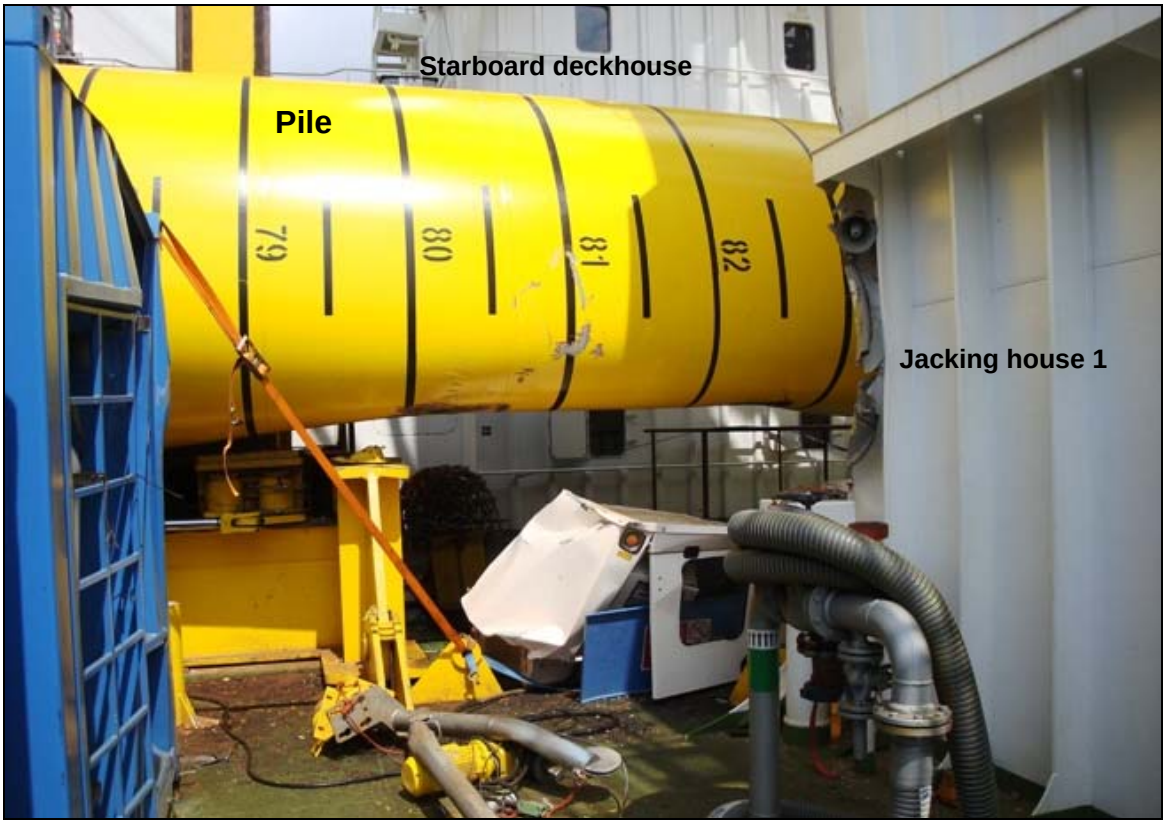

Figure 5: Damage on the upper deck[8]

[7] Jacking houses (see Figs. 3, 4, 5 and 7) = the deckhouses situated at the four corners of the installation vessel, within which the platform legs move and the elevation equipment is located.
[8] Shot from the starboard side of the vessel in the direction of the pile. The damaged fairlead (see Fig. 6 below) is located behind the position of the photographer.

Figure 6: Damage to a fairlead caused by flying debris

Figure 7: Damage to jacking house 1[9]

[9] Shot from the starboard side of the vessel to the front (= longitudinal direction of the pile).

The pile itself was significantly deformed due to slamming heavily onto the deck **(Figs. 8** and **9).**

Figure 8: Deformed pile[10]

Figure 9: Deformed pile (from below)

[10] Shot alongside from fore to aft. Deformation of the originally circular cross-section of the pile is clearly visible.

3.2.3 Environmental pollution

The environment was not affected by the accident. No pollutants escaped.

3.3 Investigation

3.3.1 Preliminary notes

The accident was reported to the Federal Bureau of Maritime Casualty Investigation (BSU) on 26 May 2010 by Waterway Police Emden. On 27 May, WIND LIFT 1 was surveyed in the repair yard by an investigating officer from the BSU. Talks were held with witnesses and representatives of the Bard Group.
To begin with, it was necessary to clarify whether the accident on board the WIND LIFT 1 could be classified as an incident involving the operation of a vessel in maritime navigation within the meaning of art. 1 para. 2 SUG, and therefore as a marine casualty and thus an event requiring investigation by the BSU. This was unclear on account of the two opposing operating conditions (stationary platform/ship) in which the installation vessel is able to operate and, in particular, due to the fact that the pile fell while she was in the platform operating condition. The results of the inspection of documents and certificates issued by the classification society and the Ship Safety Division (BG Verkehr)[11] (see sub-para. 3.3.3 et seq. below) were ultimately used provisionally as a basis for confirming the competence of the BSU in terms of investigating the accident[12] and addressing the cause of the pile falling (see sub-para. 3.3.7).

3.3.2 Description of the WIND LIFT 1

Construction of the WIND LIFT 1 signifies the realisation of a relatively new vessel concept, which was developed specifically for the special requirements involved in erecting wind turbines offshore. The underlying idea is to combine the benefits of an elevating platform over a floating facility, i.e. the possibility of assembling marine structures, to a certain degree independent of sea state and wind, safely, with the advantages of a special purpose ship, which is not reliant on tug assistance and can be positioned very precisely. To fulfil her purpose, the WIND LIFT 1 is equipped with an elevating system (so-called 'jacking' or 'jack-up system), which operates using four legs and can lift approximately 8,000 t. After lowering the legs to the seabed, the vessel is able to lift herself out of the water and in so doing becomes a stationary working platform. Four pivoting rudder propellers enable the WIND LIFT 1 to sail independently to the particular site at sea and in conjunction with the automatic positioning system[13] take up the exact platform site for the construction/maintenance of individual wind turbines.
In constructing the WIND LIFT 1, the Lithuanian shipyard realised a project of the kind described for the first time. The following data sheet provides information on the vessel's key parameters.

[11] The Ship Safety Division (BG Verkehr) is the flag state authority in the Federal Republic of Germany and is, inter alia, responsible for issuing certificates.
[12] See chapters 4 and 5 below for observations concerning the final classification of the accident as a marine casualty within the meaning of the SUG.
[13] So-called dynamic positioning system (abbreviated 'DP').

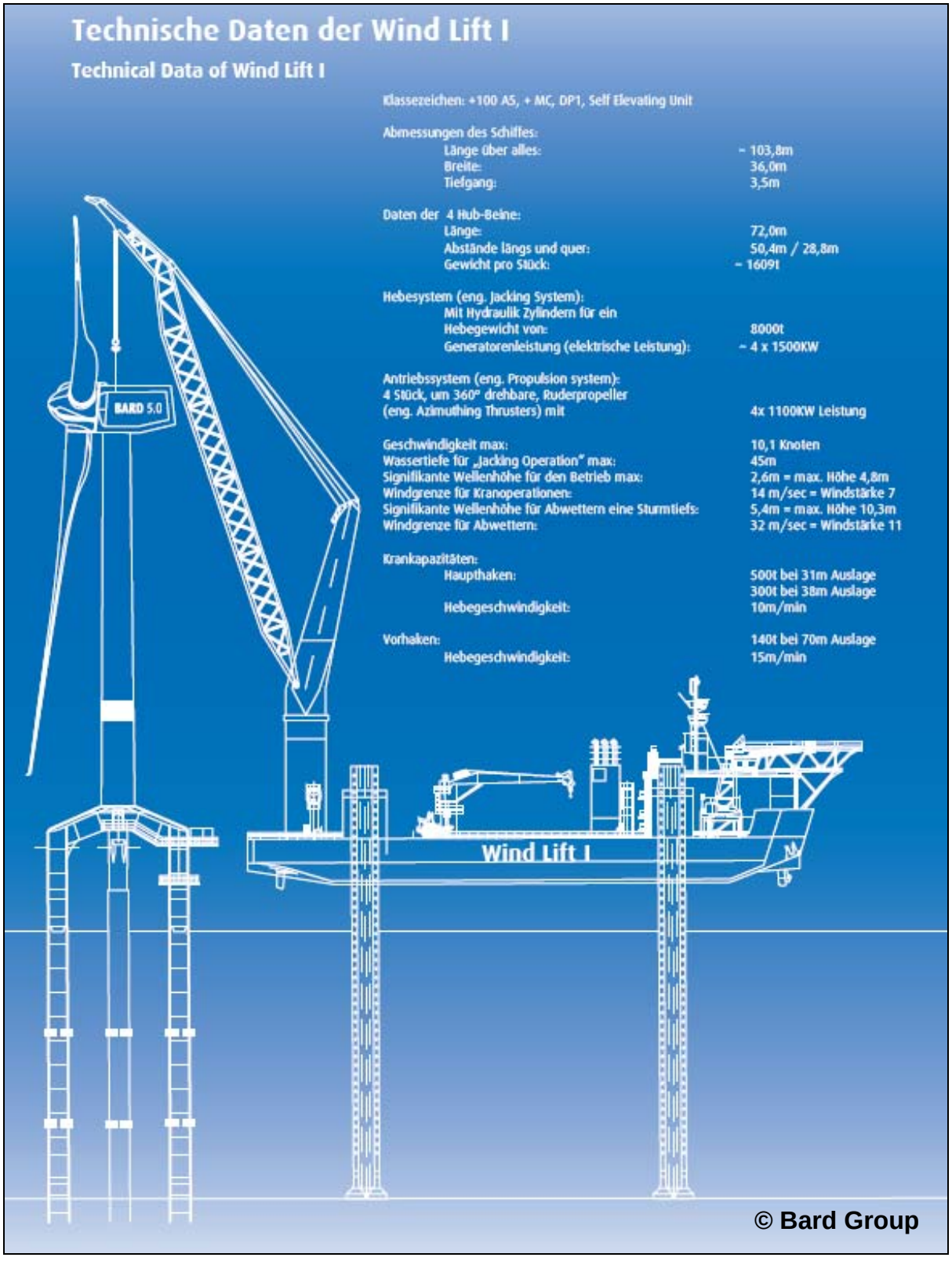

Figure 10: Data sheet WIND LIFT 1[14]

[14] Source: http://www.bard-offshore.de/de/presse-center/datenundfakten.

3.3.3 Classification

Based on the plan inspection of the classification society (GL) and a survey in Emden on 27 March 2010 at the time of the accident, the WIND LIFT 1 was in possession of an interim certificate of class as a sea-going ship with the class notation ✠100 A5 DP1 S2D11 Self Elevating Unit, ✠MC AUT valid until 14 August 2010.
According to GL, the WIND LIFT 1 has been tested and approved for both operating conditions in accordance with the safety requirements of the IMO MODU Code of 1989[15].

3.3.4 Inspection of the documents of the Ship Safety Division (BG Verkehr)

While studying the records of the Ship Safety Division (BG Verkehr), it became clearly apparent that in the several years of complex licensing and certification procedures for commissioning the WIND LIFT 1 under German flag, there were uncertainties amongst the parties involved (shipyard, client, Ship Safety Division (BG Verkehr) classification society, Federal Maritime and Hydrographic Agency) in many different contexts. In particular, this was due to having little experience in dealing with the specific issues that the aforementioned new concept of a 'wind turbine installation vessel' gave rise to. This was compounded by the fact that existing, respectively, forthcoming relevant international legal standards provide only limited answers to questions in connection with the hybrid status of the project (a sea-going ship on the one hand, a stationary platform on the other).

Without going into detail at this point (due to being irrelevant to the course of the accident), regarding the existing legal uncertainties the following points of debate are mentioned *by way of example*:

- Minimum safe manning certificate (admissibility to depart from the regularly provided manning level for 'underway' due to the specific purpose?)
- Shipbuilding standards which determine the quality of life of the crew on board a sea-going ship and are subject to legal requirements (for example, passageway width, ceiling height, natural light in the mess) versus special design requirements due to use as a working platform and 'barge' for special personnel
- Regulation-compliant arrangement of navigation lights and radar antennas as well as installation of the compasses, for example, problematic because of shadowing effects caused by the helicopter landing pad, heavy crane, legs
- Other design features that stem from the platform role and affect, for example, the requirements for navigation bridge visibility and fire protection significantly

[15] MODU Code = Code for the Construction and Equipment of **M**obile **O**ffshore **D**rilling **U**nits.

3.3.5 Certificates[16]

3.3.5.1 Interim sailing permit

Since firstly the shipbuilding and navigational requirements for a vessel to be used on international voyages were not fully met at the time of the planned commissioning, and secondly the WIND LIFT 1 was to commence operations in the wind farm as soon as possible after being transferred from the shipyard to Germany, the Ship Safety Division (BG Verkehr) decided to issue the WIND LIFT 1 with an interim sailing permit valid until 15 August 2010 for the shipping range 'national shipping'.

The following restrictions, conditions and provisions were applied[17]:

1. *National coastal shipping, including Bard wind fields in the German Bight (BSH approved).*
2. *Must be accompanied by a leading escort vessel fitted with AIS. The WIND LIFT 1 must keep to the navigation channel of the escort vessel and maintain sufficient distance to manoeuvre. Communication between the escort vessel and WIND LIFT 1 must be ensured.*

3.3.5.2 Special purpose ship safety certificate

In addition, the Ship Safety Division (BG Verkehr) issued a special purpose ship safety certificate for the WIND LIFT 1 in accordance with the requirements of the SPS Code[18]. This was also valid until 15 August 2010. The sea areas in which the vessel may operate, A1 and A2 (see SOLAS Chapter IV Regulation 2), are shown in the certificate[19].

An annex containing the following text was appended to this certificate[20]:

1. *This is to certify further that the foregoing platform under the applicable rules of the Code for the Construction and Equipment of Mobile Offshore Drilling Units, 1989, was properly inspected. For this purpose, an annual survey must be conducted in the course of an ongoing inspection programme by the relevant classification society. It is to be noted in a survey report that the construction and equipment requirements from the MODU Code are met and that any discrepancies are determined and corrected.*

2. *The survey revealed that the hull, equipment, fittings, arrangement of the radio equipment and materials of the platform and their condition are satisfactory in all respects and that the platform complies with the relevant provisions of the Code.*

The additional reference to the provisions of the MODU Code within the framework of certification in the form of an annex is to account for the fact that when the

[16] Only the certificates relevant to the investigation are addressed.
[17] In the following quoted from the sailing permit.
[18] SPS Code = Code of Safety for **S**pecial **P**urpose **S**hips.
[19] Refer to sub-para. 4.2 for more details.
[20] In the following quoted from the special purpose ship safety certificate.

forthcoming MODU Code (2012 amendment) enters into force, the simultaneous issue of two certificates, i.e. one according to the SPS Code and one according to the MODU Code, is no longer provided for.

See preamble to MODU Code 2012:

"[…] It is not intended that the provisions of the Code of Safety for Special Purpose Ships be applied in addition to the provisions of this Code."

In preparing the certificate in this manner, the Ship Safety Division (BG Verkehr) aimed to ensure that both the ship operating condition of the vessel with her own propulsion and personnel on board who are not crew members according to the SPS Code as well as the structural requirements for the platform operating condition comply with international standards and can also be monitored at all times in the future.[21]

3.3.5.3 Safety management certificate

The WIND LIFT 1 was in possession of a valid safety management certificate (SMC) in accordance with the requirements of the **I**nternational **S**afety **M**anagement Code (see SOLAS Chapter IX) at the time of the accident. While reviewing the ship safety manual[22] on which the certificate is based, it was noted that safety organisation in relation to the ship operating condition was addressed very clearly and extensively; however, there were no instructions whatsoever regarding operating procedures relating to the platform operating condition. The manual contained neither routines and responsibilities for using the dynamic positioning system and the 'jacking-up' procedure, nor a description of the operating procedures or specification of the responsibilities for the installation operating condition.[23]

3.3.6 Responsibilities on board

The ISM manual describes the powers and responsibilities for the ship operating condition and defines the seniority of the master. However, responsibilities relating to the platform operating condition were not included in the manual; furthermore, it was not possible to clarify these responsibilities conclusively via the observations and questions of the investigating officer on board the WIND LIFT 1. With regard to this – especially for the ship's command – unsatisfactory situation and the associated de facto and legal risks, shortly after the vessel commenced installation operations (April 2010) and in response to, inter alia, minor safety-related incidents, the operator sought clarification from the Ship Safety Division (BG Verkehr). In an informal response by email, the operator was informed that responsibility on the WIND LIFT 1 when in the platform operating condition could also be assumed by the site supervisor or another responsible party apart from the master.

[21] Source: Memorandum Ship Safety Division (BG Verkehr) dated 22/01/2010.
[22] The names **s**afety **m**anagement **s**ystem manual or ISM manual, for example, are used synonymously.
[23] While there are extensive documentation and checklists for the installation operating condition, including a health and safety manual, these were kept only by the site management.

3.3.7 Investigations on the cause of the fall

3.3.7.1 Preliminary notes

The WIND LIFT 1 had been operating at the 'BARD Offshore 1' wind farm since April 2010. The wind farm is to be established on an area of 59 km² about 89 km north-west of the island of Borkum and 126 km west-north-west of Helgoland at a depth of approximately 39 to 41 metres. Completion is scheduled for 2012. Construction and operation of 80 wind turbines (WT) with a rated capacity of 5 MW and a total capacity of 400 MW is planned. Each WT stands on a three-legged base, is about 152 metres high[24], and has a rotor diameter of 122 metres. The accident occurred while the second pile of the sixth wind turbine was being erected, meaning the special personnel on board had already gained experience from setting 16 piles.[25]
The special personnel working on board are divided into two construction teams, each made up of 13 people, who work for 12 hours in a dual-shift system and are usually replaced after two weeks. The next rotation of the teams was planned for the day after the accident. The findings of the BSU indicate that the special personnel are qualified employees who have experience in constructing wind turbines ashore, but have no special qualifications or experience relating to the activities on board offshore platforms or vessels. Each team is directed by one site supervisor and each supervisor is assisted by one deputy. The site supervisor or his deputy bears responsibility for the operating procedures on the platform during his shift. These individuals have no nautical or marine engineering training either.

3.3.7.2 Technology for setting a pile (summary)

A pile is set using the shipboard crane. A special hydraulically operated pincer-like gripping device (referred to on board as an 'upending tool' or 'fox') is attached to this. Based on the fore-and-aft direction of the vessel, the fox grips into the upper forward end of the pile[26]. The pile is then raised slowly on one side, pushed out about 15 metres over the stern of the platform, and in the process gradually 'tilted' into the water. The immersed end of the pile is prevented from slipping uncontrolled into the water by a special holding system installed at the rear of the platform, in particular, a claw which grips the underside of the pile.

[24] Total height calculated from the seabed, i.e. about 112 metres of the wind turbine protrudes from the water at a depth in the construction area of about 40 metres.
[25] Note: However, in this regard it must be considered that individual employees would probably have had only limited experience in setting the piles owing to the shift changes and rotation of the special personnel.
[26] Note: 'Upper end' refers to the end of the pile which is subsequently in the direction of the water surface.

The pile is abruptly slid fully into the holding device after reaching an elevation angle of about 35 degrees[27]. The pile is lowered into the water via a so-called upending saddle and gradually put into a vertical position in the course of the lifting process.
After the pile is completely upright, it is precisely aligned by means of a so-called template that surrounds it and then driven into the seabed with the vessel's pile driver (see **Fig. 11 et seq. below).**

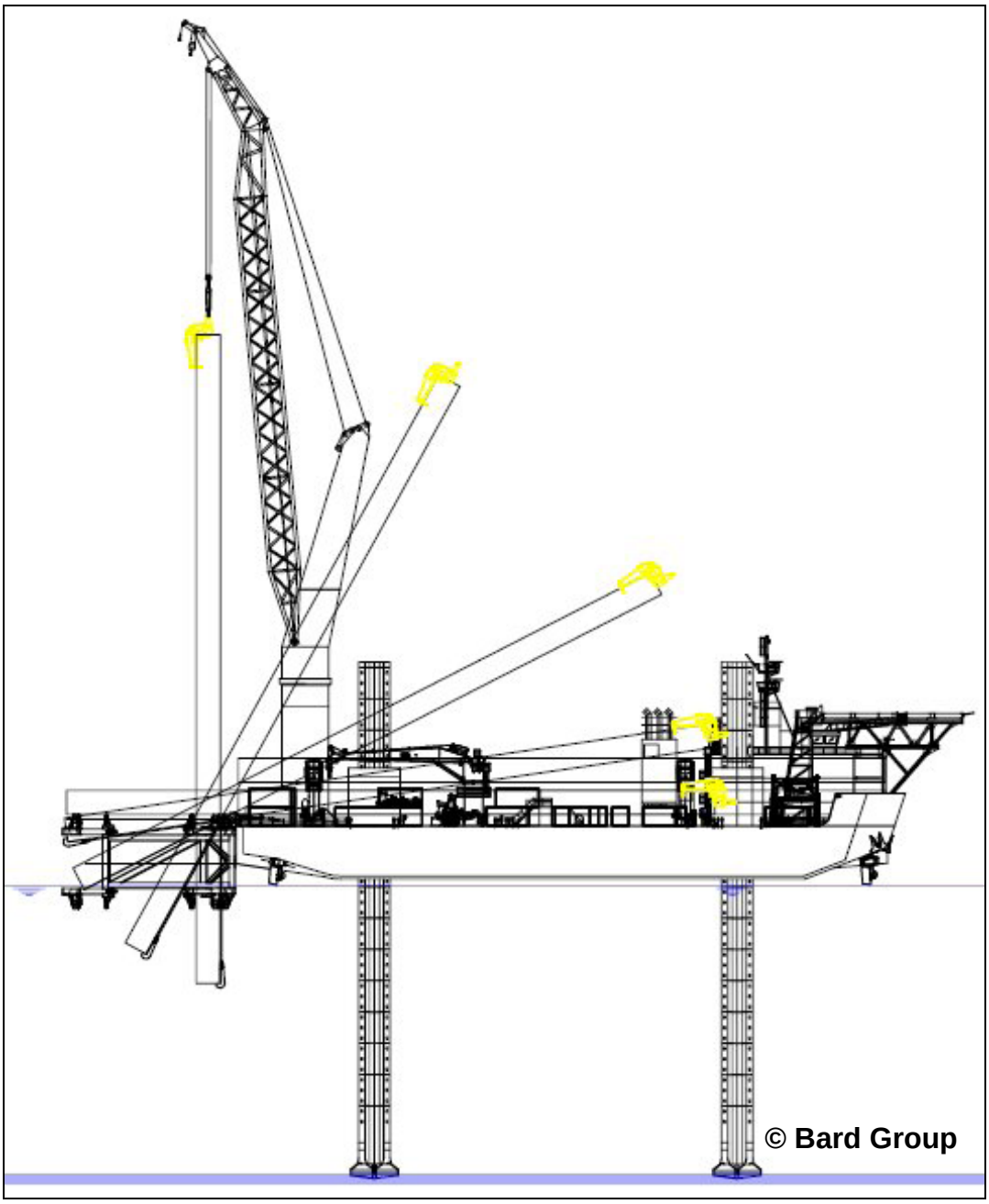

Figure 11: Diagram of a pile being set[28]

[27] This angle is calculated by applying an estimated drop height of 40 metres and a length of the pile of 85 metres (presumed 'rotation point' about 15 metres from the bottom end of the pile); engagement and drop should occur in close temporal relation.
[28] This figure was taken from the document 'Amended operating procedure for pile installation' of 17/06/2010 provided to the BSU by the operator.

Figure 12: Template

Figure 13: Upending saddle

Figure 14: Close up of the holding system

3.3.7.3 Investigation of the gripping device (fox)

3.3.7.3.1 Design and functioning

The gripping device (hereinafter referred to as fox) produced by Dutch manufacturer IHC Merwede is a so-called active lifting device[29]; its main element is two clamping jaws which are pressed together hydraulically (see **Fig. 15 et seq.).** A firm connection between the pile and crane is implemented by the pincer-like fox gripping into the top of the pile with a hydraulic pressure of at least 250 bar.
The fox is stored on deck on a specially adapted rack and is only attached to the shipboard crane for lifting the pile. The associated hydraulic drive, the so-called power pack, along with the operating unit (including wired remote controller) and two pressure gauges are located on an operating platform, which is positioned on the rotatable part of the crane column directly across from the crane cab (see **Fig. 17).** Hydraulic hoses, which are guided manually by the person operating the hydraulics when the crane jib, respectively, load is lifting, lowering and rotating, lead from the platform to the fox. The person operating the hydraulics receives instructions by radio.

[29] Active load lifting device = an appliance that does not belong to the lifting gear (in this case the crane), which can be connected to the lifting gear's carrying device (in this case the crane hook) for receiving and releasing the load and which possesses its own drive for gripping the load.

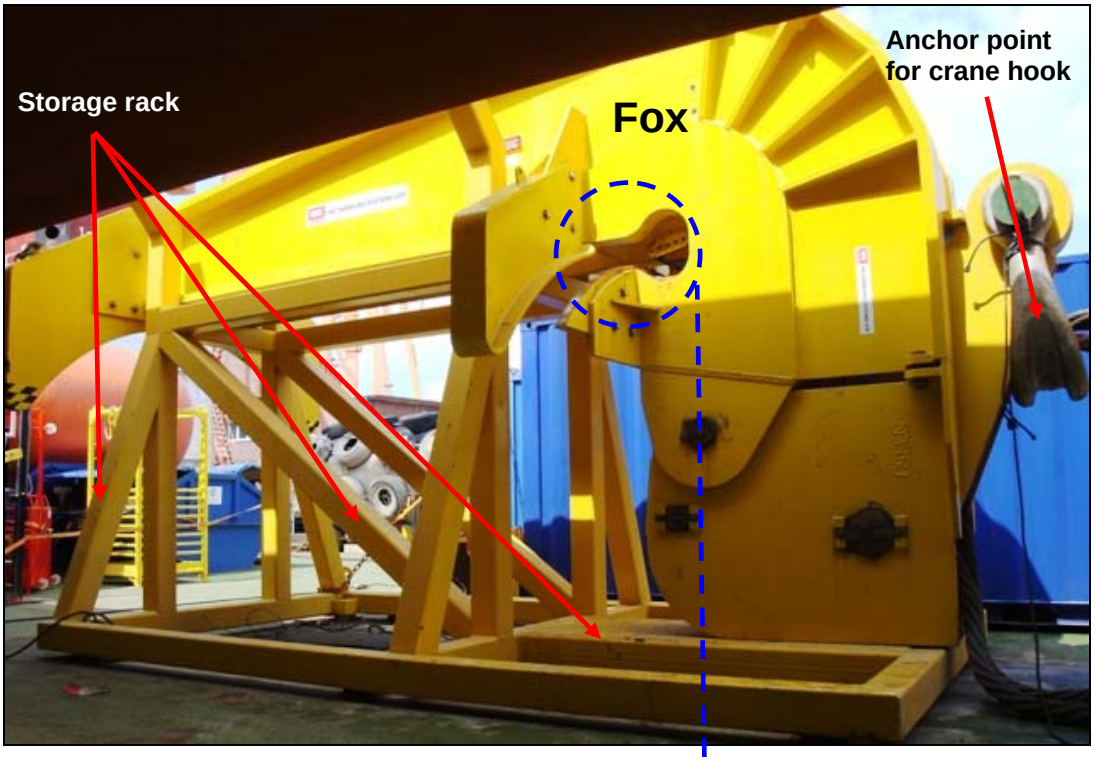

Figure 15: Fox

Figure 16: Clamping jaws (close up)[30]

[30] Note: When the proper pressure is applied, the contoured surface of the clamping jaws causes ridges on the contact area of the surface of the pile.

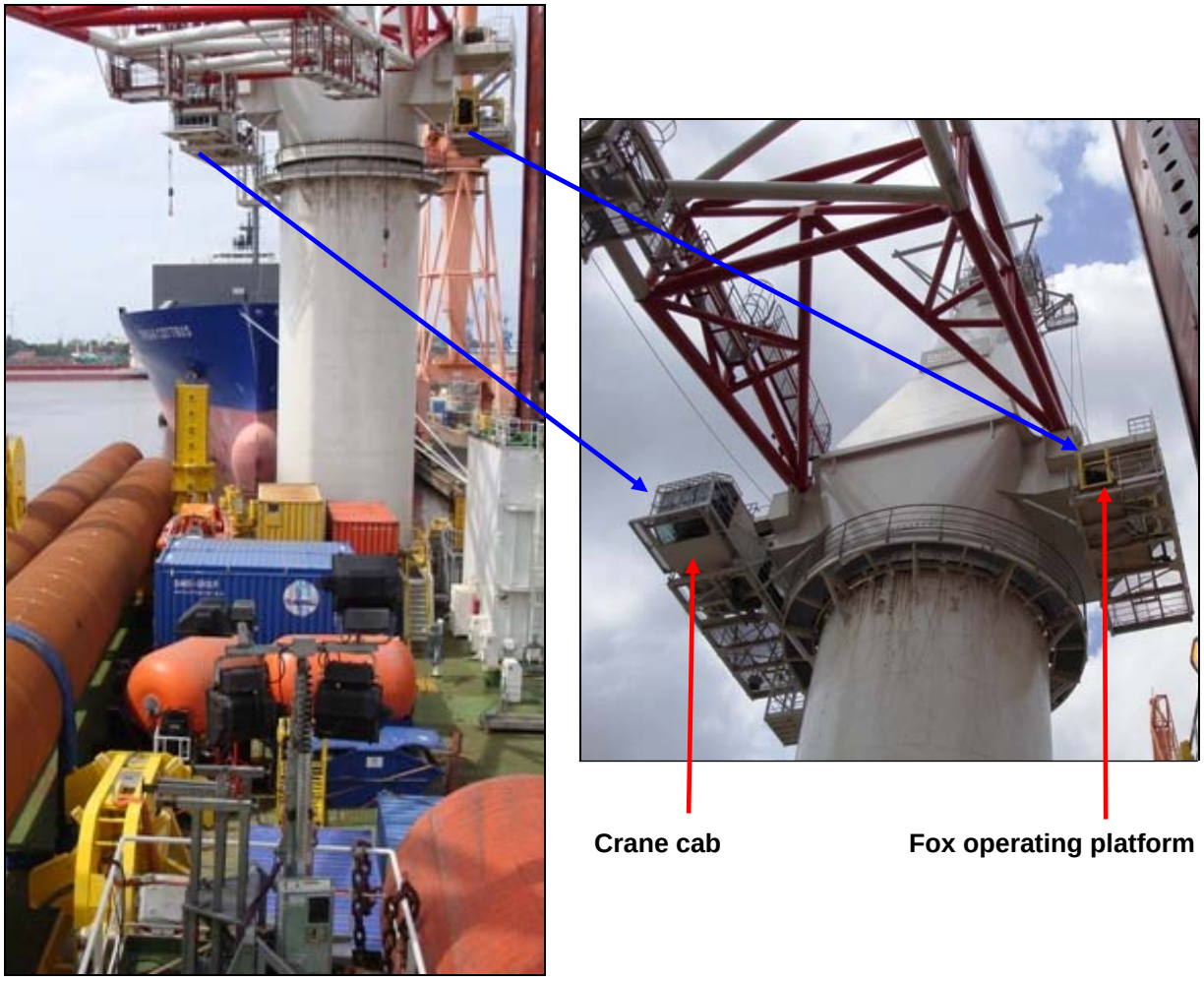

Figure 17: Crane column with crane cab and fox operating platform

3.3.7.3.2 Operation – Instructions of the operator[31]

Before the fox is fixed to the pile, pressure must be applied to the system and a performance test carried out. A test report with a checklist must be completed on board before any lift at a new site for this purpose. The following tests are prescribed, must be successfully completed, and according to the signature area confirmed by the site supervisor and the safety manager[32]:

1. *Make all connections and test the pressure of the power pack*
2. *Open 'ball valve' and put the system under pressure*
3. *Raise system to 250 bar (depending on winter (230 bar) or summer (270 bar))*
4. *Confirm that clamping jaws close*
5. *Close 'ball valve' and maintain pressure for 10 minutes*
6. *Check whether pressure is still at 250 bar*
7. *If pressure is not at 250 bar, increase to 250 bar and check pressure again*
8. *'Ball valve' must be closed, then remove the hose*

[31] Bard Group.
[32] Taken from the original test report from the day of the accident.

Next to a 'Comments'[33] field, the report essentially states that test steps 1 to 4 must be repeated after the fox is fixed to the pile and that the pressure must be monitored constantly during the lift.
Several witnesses stated that the function test would have also involved a visual inspection, which is not included in the aforementioned checklist, after the fox was fixed to the pile. This would reportedly involve the clamping jaws being re-opened after the initial build-up of pressure and, using a ladder, the surface of the pile being checked for pronounced indentations (ridges). Reconstruction of such an inspection (see **Fig. 18)** proved to be very difficult and hardly practicable due to the size of the ladder available on board. Therefore, it remained unclear whether such an additional visual inspection was actually part of the regular operating procedure.

Figure 18: Inspection of the pressure marks[34]

The following personnel from the respective construction team cooperate closely during the testing and mounting of the fox:

- Site supervisor (or deputy)
- Workers
- Hydraulics operator
- Crane operator

At the same time, the site supervisor (or his deputy) communicates with both the crane operator and the hydraulics operator on a VHF working channel[35] and issues the necessary instructions.

[33] Evidently, the names of the individuals who conducted the test are entered here.
[34] Photo shows the subsequent search for pressure marks during the local survey by the BSU.

3.3.7.3.3 Operation on the day of the accident

The findings of the BSU indicate that the tests described above were not fully implemented on the day of the accident. Indeed, all the parties involved unanimously reported that for the functioning of the fox a pressure of 280 bar had reportedly built-up before *and* again after it was mounted without difficulty. However, the additional visual check (inspection of the indentations on the surface of the pile) had reportedly not taken place. If one disregards the existing doubt that such an inspection is part of the regular procedure, the reason for this could, in addition to or instead of negligence or time constraints, be the fact that a shift change occurred between the last function test, i.e. the one before the fox was mounted (pressure test) and the one after the fox was mounted. The issue of the additional visual inspection was not explicitly addressed during the shift change. That the new shift erroneously assumed the visual check of the indentations had already been performed by the old shift is something that cannot be excluded.

An assessment of the supposed pressure marks on the surface of the pile after the accident revealed that in contrast to the inner pressure position **(Fig. 19)**, the clamping jaws left no indentations on the outer pressure position painted yellow **(Fig. 20)**.

Figure 19: Clamping jaw pressure mark (inner surface of the pile)

[35] Note: Rather than a marine channel, a VHF radio channel is used for service communications.

Therefore, it must be assumed that the pile was not held properly by the clamping jaws. The ridges found on the inner surface of the pile (see area highlighted in red on **Fig. 19**) in spite of that were probably caused by pressure from the 'lower' clamping jaw on the inner surface of the pile, which inevitably built-up while the pile was being raised.

Figure 20: Outer surface of the pile (no pressure marks)

The operator provided the BSU with photos, which were reportedly taken immediately after the accident. Shown are the digital pressure gauge on the fox's wired RCU and the analogue pressure gauge on the housing of the power pack (see **Figs. 21** and **22**) with values of 265.7 and about 273 bar.

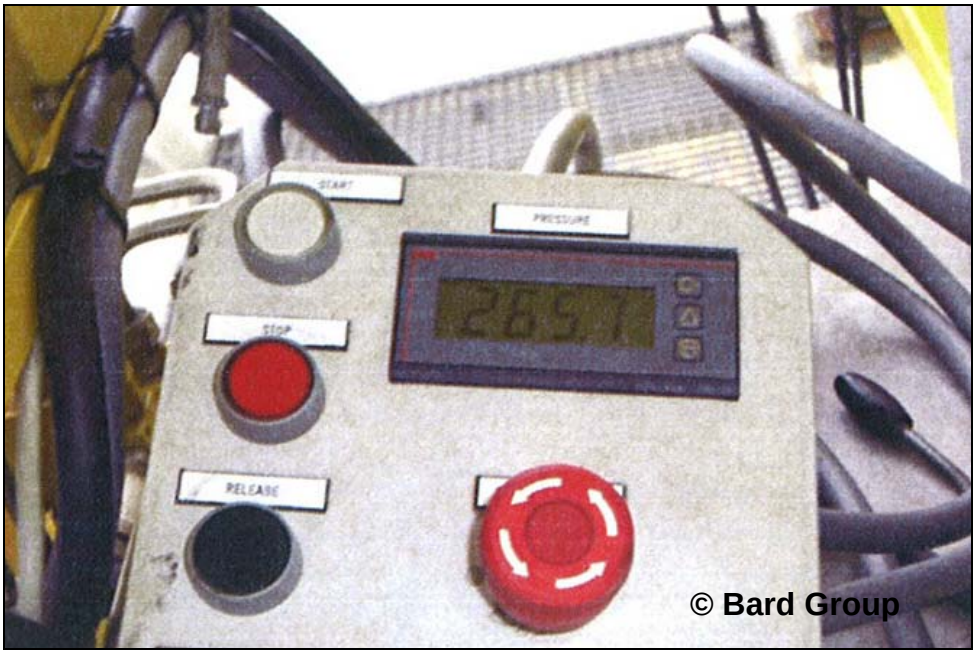

Figure 21: Fox's wired RCU – digital pressure gauge

Figure 22: Analogue pressure gauge on power pack[36]

3.3.7.3.4 Investigation by the manufacturer

After the accident, the fox together with fittings was transported to the manufacturer and underwent very extensive functional testing.[37] Malfunctions were not found. The ostensible contradiction between the witness statements and the values on the pressure gauges in the photographs on the one hand and the fact that for lack of pressure marks on the surface of the pile one must assume that the clamping jaws were not properly closed on the other could be explained by the manufacturer, according to which the discrepancy between the displayed pressures and the apparent lack of pressure on the clamping jaws was caused by a design feature. This is that a continuous hydraulic hose connection does not exist between the fox and the power pack. Instead, the fox is connected to the power pack via a quick-release coupling system. A safety valve is integrated into the coupling (= side leading to the power pack), which closes when the fox is disconnected. This is to prevent hydraulic fluid from escaping and ensure that the working pressure is maintained. After the fox has been properly connected to the power pack, the safety valve should open automatically, allowing the hydraulic pressure to reach the clamping jaws.

[36] Figs. 21 and 22 are taken from the 'Technical report of 15/06/2010' on the accident provided by the operator to the BSU.
[37] Note: Corresponding test logs were provided to the BSU by the operator.

If the safety valve does not open after the fox has been connected due to a technical fault or because the coupling has not been properly implemented, this inevitably leads to the prescribed operating pressure being reached and displayed on the power pack; however, the build-up of pressure only reaches the safety valve, but not the fox. From looking at the pressure gauge, personnel would be led to believe, erroneously, that the clamping jaws are under pressure, even though they are not actually closed properly.

3.3.8 Manning

WIND LIFT 1 possesses a minimum safe manning certificate in accordance with international[38] and national[39] requirements, according to which she was properly manned at the time of the accident.

3.3.9 Weather

The BSU requested an official report on the weather conditions from Germany's National Meteorological Service, Hamburg. This indicated that calm spring weather prevailed on the day of the accident. There was a generally light wind blowing from the north-west, later west (3 to 4 Bft) and the height of the swell stood at a maximum of 1 metre.

[38] SOLAS Chapter V/14(2), IMO Resolution A.890(21), STCW.
[39] Schiffsbesetzungsverordnung (Ships' Crews Regulation) 1998.

4 ANALYSIS

4.1 Classification of the accident as a marine casualty

It has already been discussed above in sub-para. 3.3.1 that classifying the accident on board the WIND LIFT 1 as a marine casualty was problematic. On the one hand, the incident occurred on a vessel classified as sea-going, on the other hand, she was operated as a stationary platform at the time of the accident. Therefore, doubts may arise as to whether the falling pile was an "incident involving the operation of a vessel in maritime navigation which has caused damage or danger"[40] within the meaning of the German Maritime Safety Investigation Law.

In addition to the operating condition deviating from that of 'ship', the fact that neither other vessels nor the vessel's crew members were actively or passively involved in the accident could also oppose classification as a marine casualty. Moreover, the accident involved a purely platform-related activity (so-called installation operations).

However, such an isolated view of the events on board the WIND LIFT 1 fails to acknowledge the fact that it is thanks only to fortunate circumstances that the falling pile had relatively minor consequences. Had the drop height been greater and/or the drop angle back to the deck more unfavourable, then the consequences for all on board, for the preservation of the vessel as a whole, and for the marine environment could have been severe.

In view of the high level of risk to which the crew and vessel – and moreover in the open sea – was clearly exposed, all in all it appears to be inappropriate to oppose classification of the accident as a marine casualty merely because it occurred in an operating condition other than that associated with conventional use of a vessel and/or because crew members remained uninjured, because the WIND LIFT 1 did not sustain damage so heavy that she may have been lost or because the marine environment was not affected. Moreover, the WIND LIFT 1 was returned to the ship operating condition a relatively short time after the accident.

A different approach would inevitably have led to random results, which would have focused on the specific realisation of the particular accident risk. Random results would also be conceivable with incidents that occurred on the immediate threshold between the platform and the ship operating condition, during the jack-up procedure or in heavy weather, for instance.
Therefore, the starting point for affirming or opposing the context of ship operation may only be the question of whether an incident is basically capable of jeopardising the option of short-term discontinuation – which may be independently restored at any time – of the ship operating condition by jacking-up in the open sea, as intended by the systems in place.

[40] So-called context of ship operation.

Such an approach also covers 'mere' risks for crew members, because in the opinion of the BSU establishment of the proper ship operating condition in the above sense implies the continuous presence and operational readiness of manning, which conforms to the minimum safe manning certificate. Furthermore, at least to the extent that it concerns the permanent presence of a vessel's crew, the owner, the operator and the Ship Safety Division (BG Verkehr) have apparently recognised that one such must also be on board in accordance with the requirements of the Ships' Crews Regulation in the platform operating condition.

Regarding the possibility of the crew establishing the ship operating condition at any time and at short notice on its own, the assessment of an incident on a unit classified as a sea-going ship and temporarily operating as a platform is substantially different to an accident involving a vessel docked in a shipyard. First, the open sea is not affected, and second, when docked the competence for returning the vessel to her normal operating condition inevitably and by the very nature of things transfers from the crew to the operator of the shipyard. Therefore, not classifying an accident involving a vessel docked in a shipyard as a marine casualty while at the same time classifying an accident on a jacked-up installation vessel as ship operation does not signify a discrepancy.

Therefore, to summarise it must be noted that the falling pile was an accident which, based on the following factors, can be regarded as being "in the context of the operation of a vessel in maritime navigation" and thus classified as a marine casualty:

1. Scene of the accident in the open sea on a vessel classified as sea-going
2. Option of transferring from the platform operating condition to the sea-going ship operating condition independently as approved by national and international certificates at any time and at short notice as intended by the systems in place was put at risk
3. The crew, the special personnel under the protective scope of the SPS Code and the substance of the sea-going ship as a whole as well as the marine environment were put at risk

4.2 Licensed service area/legal consequences

Both the provisional sailing permit[41] and the special purpose ship safety certificate contain requirements concerning the licensed service area, but these are not the same. Further differentiation can be found in the sailing permit. While the front of the permit merely refers to the WIND LIFT 1 operating in 'national shipping', the licensed area of operation is extended on the back of the permit to the Bard wind fields in the German Bight (i.e. the EEZ, which is outside German territory)[42]. On the other hand, the safety certificate permits operation in the sea areas A1 and A2, i.e. in an area which according to SOLAS Chapter IV Regulation 2 No. 1.12 et seq. reaches far beyond both the territorial sea and the EEZ. Hence, the WIND LIFT 1 also falls within the strict scope of application of SOLAS Chapter V without the Administration being

[41] Operating licence for a sea-going ship in accordance with art. 46 Accident Prevention Regulations (UVV See) (rule expired 1 January 2011).
[42] EEZ = **E**xclusive **E**conomic **Z**one.

able to apply more extensive restrictions than the rules provide for in certain cases[43].[44]

4.3 ISM

4.3.1 Legal requirements

The measures provided for in SOLAS Chapter IX for the Safe Operation of Ships (**I**nternational **S**afety **M**anagement Code) are binding for vessels flying the German flag. Due to these rules and regulations, all owners are obliged to implement and maintain a *comprehensive* and *seamless* system for safety management.
The company is required to keep a written record of *all the functions and activities, which concern safety or protection of the environment on board its vessels* and ensure that they are planned, organised, executed and monitored in compliance with legal and operational requirements. This involves the implementation of procedures for the preparation of plans and instructions for key shipboard operations concerning the safety of the ship. The safety management system should provide for measures with which it is ensured that the relevant stations can respond to hazards, accidents and emergency situations at any time. The documentation which facilitates description and implementation of the system used for the organisation of safety measures (emergency planning) can be summarised into a safety management manual, in which the entire **s**afety **m**anagement **s**ystem is described.

4.3.2 Implementation on board the WIND LIFT 1

As described in sub-para. 3.3.5.3, the safety management system in place on board at the time of the accident provides for the safety organisation relating to the ship operating condition clearly and comprehensively and to that extent also defines, for example, the powers and responsibilities of the ship's command in detail; however, the procedures and powers relating to the platform operating condition and switching operating conditions (platform/sea-going ship) are not addressed by the safety management system.

4.3.3 Evaluation

Evaluation of the safety management system relevant at the time of the accident is closely connected with the considerations made in the course of classifying the accident as a marine casualty in a legal sense. From the derived conclusion that safe ship operation may also be adversely affected by accidents when the WIND LIFT 1 is in the platform operating condition, it is a logical consequence that a regulation-compliant, i.e. *comprehensive* and *seamless,* system for safety management on board the WIND LIFT 1 must also include the main operating procedures associated with her use as a lifting platform.

[43] Note: According to SOLAS Chapter V Regulation 1 No. 2, application of Chapter V may only be restricted by the Administration for those vessels which operate exclusively in waters landward of the baselines.
[44] Since the regulatory requirements for the licensed service area are not relevant to the accident, the BSU is not addressing this issue further.

This applies at least to the extent that it entails risks, the materialisation of which could jeopardise the crew and the ship operating condition.

4.4 Authority on board

The owner and the operator assumed – with the explicit approval of the Ship Safety Division (BG Verkehr) – *"that when the WIND LIFT 1 was in 'jacked-up' condition, responsibility could also be assumed by the site supervisor or another responsible party apart from the master."*[45] It is questionable whether this wording aims to permit responsibility remaining with the master, or even fully excludes this possibility.[46]
In both cases, the opinion that one could fully transfer the responsibility of the master to a site supervisor on board a sea-going ship when she is in the platform operating condition is contradicted by the derived principles above, according to which hazards and risks in the platform operating condition must also be implemented in the safety management system of the sea-going ship if these involve a potential risk to the crew or safety of the vessel. Moreover, it is important to note that the basic decision of the operator to classify a lifting platform as a sea-going ship and put this into service with the corresponding certification is also linked to an uncompromising recognition of the special position and responsibility of the master with respect to the ship's safety as defined by international[47] and national guidelines[48].
Indeed, under German Seamen's Law the master does not have authority over special personnel on board the vessel if and for as long as the work of such personnel on board does not involve the ship operating condition[49], meaning that doubt could be cast on his authority in respect of the activities of the special personnel. However, the Seamen's Law also provides that the master must ensure the maintenance of order and safety on board and is entitled to implement the measures necessary for this; even using coercive measures in the event of imminent danger to people or vessel.[50] Since the relevant provisions of the Seaman's Law represent peremptory law[51], the BSU is the opinion that it is inadmissible for administrative decisions or internal regulations to repeal or restrict the ultimate responsibility of the master.

4.5 Notes to the installation operating condition

4.5.1 Technology

The technological procedures for the installation operating condition in the stricter sense were not looked at in detail in the investigation by the BSU.

[45] Quote from email of the Ship Safety Division (BG Verkehr) to the operator of 27 April 2010.
[46] In its statement to the draft of this report, the Ship Safety Division (BG Verkehr) emphasised that on no account did the transfer of responsibility mean that the authority of the master was repealed or restricted.
[47] See SOLAS Chapter IX in conjunction with ISM Code Part A No. 5.
[48] Seamen's Law.
[49] See art. 106 para. 1 (1) in conjunction with art. 7 para. 1 Seamen's Law.
[50] See art. 106 para. 2 et seq. Seamen's Law.
[51] See art. 10 Seamen's Law.

Activities are not regarded as being originally attributable to or impairing ship operation as long as they pose no danger to the crew or the possibility of restoring a proper ship operating condition at any time is not affected. Therefore, an investigation or evaluation of the installation technology in the strict sense is beyond the competence of the BSU.

4.5.2 Points of contact with the ship operating condition

Based on the classification of the accident as a marine casualty, the evaluation of the safety management system and the authority on board, it was established that it is not possible to draw a strict dividing line between the installation operating condition and the ship operating condition, because in many respects the hazards relating to the installation operating condition can affect the 'mother ship'. Therefore, from the perspective of a maritime safety investigation, heavy demands must also be placed on occupational safety in the installation operating condition, on the qualifications of the special personnel, and on the functionality and safety of the equipment and tools used.

The thus permissible and essential evaluation of these installation technology issues in a broad sense by the BSU gives rise to the conclusion that in addition to the technical problems addressed above, organisational deficits also contributed significantly to the development of the accident. Insufficient communication between the two shifts regarding the completed, respectively, not completed safety checks is probably the reason that the inspection of the clamping process was not performed. In addition, it should be noted in general that the awareness of the special crew in terms of occupational safety and regarding the specific characteristics of working at sea ought to be raised.

4.5.3 Operational safety – load lifting device

The investigation mandate of the BSU regarding the installation operating condition is also limited with regard to the equipment used. On the other hand, however, its operational safety must also be measured by the standard of ship safety. A key factor in the accident was the ultimately unsound pressure gauge readings for the gripping process of the fox. In addition, from the perspective of safety the basic technology-related decision to move components with a mass greater than 400 tonnes with an active load lifting device, which on one hand does not have a standby mechanism or some other fall back level and on the other hand has clamping jaws that grip only an extremely small fraction of the load surface appears to be very hazardous. It may be true that such a form of load suspension is acceptable for shore-based operation, but for shipboard operation it must be considered that there is practically no safe refuge for the personnel on board. Therefore, it is highly questionable whether the risk of technical failure of the hydraulics of the load lifting device was considered sufficiently when deciding on the selected and developed gripping system and approval thereof.

4.6 Crisis management

Immediately after the accident, the master assumed responsibility for crisis management on board clearly, resolutely, and apparently without opposition from the site management.

This is particularly noteworthy when one considers that he was effectively deprived of this responsibility on account of the regulations of the operator and the owner, as approved by the Ship Safety Division (BG Verkehr), and for lack of instructions in the ISM manual. However, that the decision to switch to ship operating condition and move to Emden was taken at the initiative of the owner and the operator without consulting with the authorities and – as far as could be determined – also without the classification society in spite of a heavy load of more than 400 tonnes falling onto the deck is problematic.

4.7 Actions taken

4.7.1 Revision to the ISM manual

The surveyor from the Ship Safety Division (BG Verkehr) had already highlighted the need for the installation operating condition to be incorporated into the safety management system of the WIND LIFT 1 in his survey record of 27 May 2010. The owner complied with this requirement at short notice and incorporated a reference to the requirements of the occupational safety manual into the ISM manual. Furthermore, several procedures (for example, 'DP operation', 'HELO operation', 'bridge communication') were added to the safety management system.

4.7.2 Modifications to the fox

The manufacturer of the fox has installed another pressure measuring point, which is located directly on the gripping device. This measuring point has been equipped with a pressure gauge. In addition, one red and one green signal light has been mounted on the gripper and connected to the new measuring point. Illumination of the green light indicates that the prescribed pressure is applied to the clamping jaws; if the pressure is not applied, then the red light illuminates.

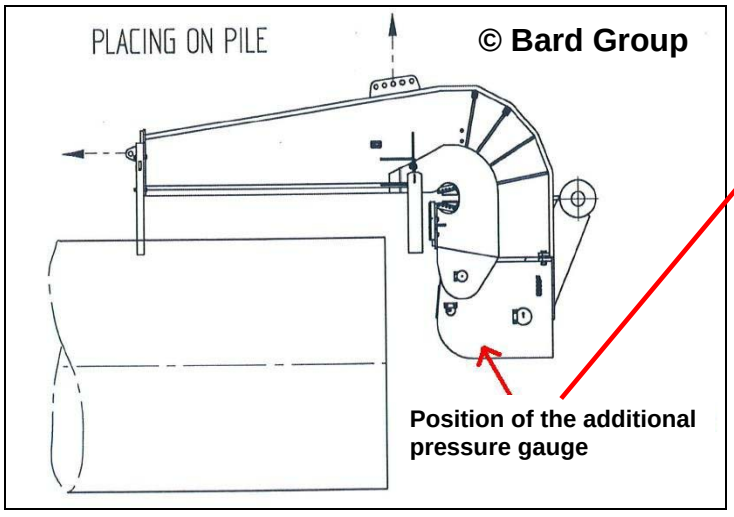

Figure 23: Position of the additional pressure gauge[52]

[52] Fig. 23 et seq. is taken from the document 'Modification of the upending tool' of 17/06/2010 provided to the BSU by the operator. Fig 23 has been slightly edited by the author of the report.

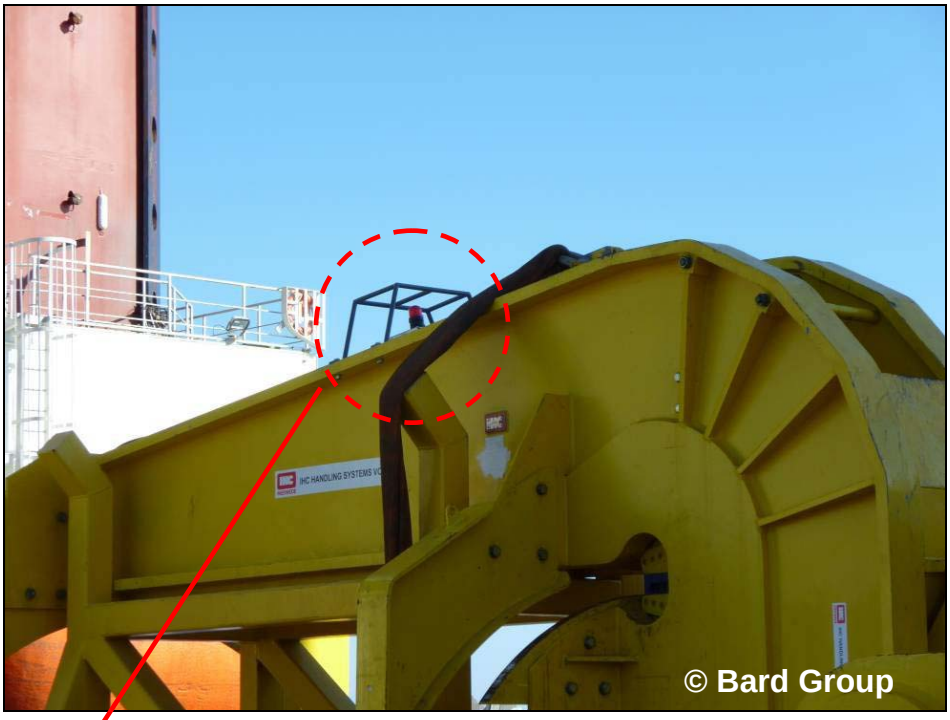

Figure 24: Signal lights on the fox

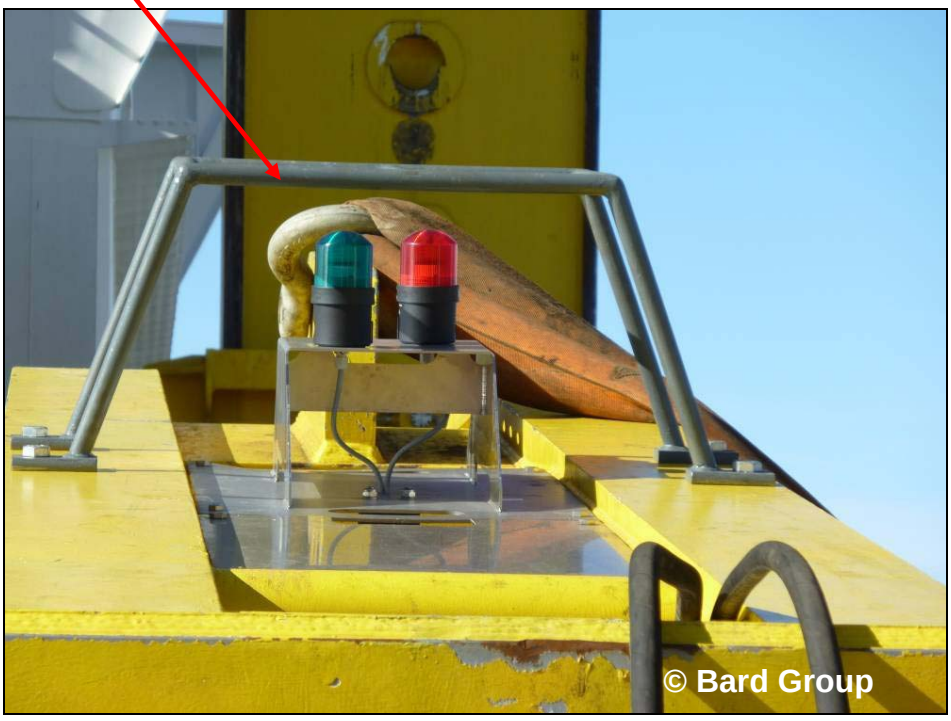

Figure 25: Signal lights on the fox (close up)

5 CONCLUSIONS

The falling pile was the result of an accumulation of design faults and human factors. In the development of the gripping device (fox), insufficient consideration was given to the potential for operator error (in this case improper coupling) or negligence by the personnel (in this case inadequate visual inspection during the function check). On the other hand, the in this event irrelevant pressure gauges at the control panel (power pack) for the conditions at the clamping jaws of the gripper provided the personnel with the misleading impression that the fox was gripping properly, even though this was not the case. Beyond that, perhaps the human outlook that one could rely on the output of measuring devices also contributed to the necessary attention not being devoted to the intended visual inspection.

Notable are the efforts of the owner, the operator and the manufacturer to immediately clarify the causes of the accident and play a constructive role after the accident. However, in that regard the question as to whether it is justifiable to move heavy loads of more than 400 tonnes with a system in which short-term failures in operation can have hardly predictable consequences remains open. This is especially true when one considers that in contrast to shore-based operations, ultimately and by the very nature of things it is almost impossible to define a less hazardous area outside the swivel range than on board an offshore platform.

It is not possible to judge whether the non-inclusion of the installation operation in the safety management system and consequent – authorised by the Ship Safety Division (BG Verkehr) – dispensation of the master as supreme authority on board with respect to monitoring observance of safety and order in the installation operating condition facilitated the accident in hindsight. Nevertheless, the paramount importance to the 'normal' ship operating condition of the legally and factually unchallenged and unrestricted command authority of the master should not be underestimated and therefore not called into question for the installation operating condition. Incorporation of the occupational safety manual into the ISM manual by the owner by way of a cross reference is a step in the right direction in this respect.

The BSU has entered uncharted territory with the investigation of the incident on board the WIND LIFT 1. As far as could be determined, no clear and unambiguous legal provisions have been implemented thus far at national or international level, which would exhaustively and consistently regulate the construction and operation of so-called 'wind turbine installation vessels'.

The classification of events as a marine casualty and the consequences for the safety of shipping derived from the investigation are therefore the result of an overall view of various provisions; however, looked at individually, in some cases these can only be applied to the particular conditions on board *installation* vessels to a very limited extent. The following problem areas are mentioned by way of example:

- Application of the MODU Code even though the WIND LIFT 1 is not a **M**obile **O**ffshore **D**rilling **U**nit
- Exclusivity between the MODU Code and the SPS Code[53]
- Master's authority to give orders to the special personnel
- Implementation of the installation operating condition in the safety management system with all the ensuing consequences

In particular, in respect of the powers of the master a fundamental problem arises from the fact that under the Seamen's Law his full authority to give orders does not apply to special personnel because they do not work on board within the framework of the ship operating condition. However, this does not alter the fact that the master has the ultimate power to issue orders relating to order and safety on board and in dangerous situations. The question now is where, within the scope of the 'routine' installation operating condition, the line is drawn between firstly work that does *not* involve the order and safety of the vessel and secondly and in that context work which is certainly potentially hazardous, respectively, whether this is at all possible.

In a "Statement on the impact of the planned development of the offshore wind farm to the safety of shipping"[54], the German Nautical Association (DNV) set out the following request under para. 10:

"The DNV points to the need for the personnel of the operator of the offshore wind farm to be adequately qualified in offshore-specific safety matters. Standard guidelines concerning this should be adopted. This also applies to vessels used for construction and servicing, respectively, operation."[55]

With this appeal it is remarkable how clearly the DNV anticipated the findings of the BSU's investigation of the accident on board the WIND LIFT 1, which were not published at the time of the statement in question.

[53] Note: This exclusivity is reflected in the preamble to the future MODU Code of 2012 (see quote p. 20) and is also already laid down as an existing law in Chapter 1, No. 1.1.2 of the Code of Safety for Special Purpose Ships of 2008: *"This Code does not apply to vessels that conform to the Code for the Construction and Equipment of Mobile Offshore Drilling Units (MODU Code)."*

[54] See www.dnvev.de 'News', 'Sailors demand more safety', THB, 07/02/2011, p. 2; HANSA, March 2011, p. 99

[55] Note: Emphasis added by the author of the report.

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 Federal Ministry of Transport, Building and Urban Development

6.1.1 Rules for the construction and operation of installation vessels

The Federal Bureau of Maritime Casualty Investigation recommends that as a consequence of the establishment of the new ship type 'wind turbine installation vessel' in international shipping, the Federal Ministry of Transport, Building and Urban Development (BMVBS), in cooperation with the classification societies, take initiatives at the IMO that are aimed at developing binding and unambiguous rules for the construction and operation of such vessels used temporarily as a lifting platform, or adapt existing legislation to the extent necessary. In the interest of improving the safety on board such units for the crew, the special personnel, the vessel and the environment it is imperative that the construction and operation of these special purpose ships, including the authority of the master to issue orders to the special personnel, be put on a legally clear and consistent footing.

6.1.2 Adaptation of the Seaman's Law

The Federal Bureau of Maritime Casualty Investigation recommends that the BMVBS review the expediency of the far reaching regulations of the Seamen's Law, under which the master only has authority over the crew members and those individuals on board who work within the *framework of the operation of the vessel*. The work of special personnel is generally potentially very hazardous in relation to the safety of the vessel, especially on wind turbine installation vessels. Elaborating on the above, it is always possible to support the fact that ultimate responsibility rests with the master; however, a more clearly defined version of the relevant standards in the Seamen's Law would ensure greater legal certainty and clarity for authorities, owners, operators, and, not least, the people on board.

6.2 Ship Safety Division (BG Verkehr), German Lloyd (GL)

The Federal Bureau of Maritime Casualty Investigation recommends that in the course of licensing and certification procedures, which concern the construction, commissioning and operation of installation vessels, the Ship Safety Division (BG Verkehr) and GL give the assurance of a safe ship operating condition *and* installation operating condition absolute priority over all other interests of owners and operators. Hazards which arise from the installation operating condition but have the potential to impair the safety of the crew and the vessel as a whole must already be provided for in the testing and approval procedures of the Ship Safety Division (BG Verkehr) and GL under current law (implied factual connection).

6.3 Owner and operator

6.3.1 Safety management system – general

The Federal Bureau of Maritime Casualty Investigation recommends that with regard to the operation of the WIND LIFT 1 and any future installation vessel, the owner and the operator of the WIND LIFT 1 account for the fact that there are hazards associated with the installation operating condition which may impact the vessel as a whole on its own initiative and prior to any amendment to legislation and permits/requirements. Therefore, regulations and safety principles formulated for the ship operating condition must be extended to the procedures for the installation operating condition in as far as possible. In this context, it is also recommended that a review be carried out on whether the gripper technology used on board, which, without standby or fall back level, requires the zero-malfunction operation of the hydraulic drive, is reasonable in relation to the dangers associated with a failure of the hydraulics in lift operation.

6.3.2 Safety management system – emergency situations in the installation operating condition

The Federal Bureau of Maritime Casualty Investigation recommends that in the course of revising the safety management system the owner and the operator of the WIND LIFT 1 establish unambiguous measures, which must be implemented *before* it is permissible to switch the vessel to the ship operating condition.

7 SOURCES

- Investigations by Waterway Police (WSP) Emden
- Oral, partly written statements
  - Ship's command
  - Owner – Wulf Seetransporte GmbH & Co. KG, Cuxhaven
  - Operator – Bard Group, Emden
- Web site of the operator
- Information, statements – Germanischer Lloyd
- Nautical chart and vessel particulars, Federal Maritime and Hydrographic Agency (BSH)
- Documentation, Ship Safety Division (BG Verkehr)
- Official weather report by Germany's National Meteorological Service (DWD)
- German Nautical Association (DNV) "Statement on the impact of the planned development of the offshore wind farm to the safety of shipping" – see www.dnvev.de, 'News'
- Photo credits: photos without a source taken by BSU, otherwise copyright held by the Bard Group