DUTCH
SAFETY BOARD

Fatal accident in cargo tank of chemical tanker

Lessons learned from the occurrence on board the NCC SAFA

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The Hague, July 2023

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The Dutch Safety Board

When accidents or disasters happen, the Dutch Safety Board investigates how it was possible for these to occur, with the aim of learning lessons for the future and, ultimately, improving safety in the Netherlands. The Safety Board is independent and is free to decide which incidents to investigate. In particular, it focuses on situations in which people's personal safety is dependent on third parties, such as the government or companies. In certain cases the Board is under an obligation to carry out an investigation. Its investigations do not address issues of blame or liability.

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N.B.: This report has been published in the Dutch and English language. If there are differences in interpretation the Dutch report prevails.

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RECOMMENDATION AND LESSONS

Based on the investigation of this incident on board the NCC SAFA, the principle 'follow the procedures' is once again underlined. In addition, the Dutch Safety Board comes to the following recommendation to the shipping company:

To Mideast Ship Management

1. Provide an inert gas system constructed so that there are multiple safety barriers. This should include a control system for the use of inert gas, whose capabilities and limitations are known to the entire crew.

In addition to the recommendation the following lessons can be learned from the incident:

1. During inspection and maintenance, the crew must be mindful of possible failure of the inert gas system due to damage. Ensure that all safety-critical components are identified and adjust the maintenance protocol accordingly. A maintenance protocol limited to only lubrication and visual inspection of part of a valve gives an unwarranted sense of being safe.

2. Crew should be able to speak up and stop work if another crew member (including the captain) does not follow a procedure. Provide a working environment where crew feel safe to do so.

3. Targeted training and education ensure that procedures can be followed and impulsive actions, where people put themselves in mortal danger, are prevented.

C.J.L. van Dam
Chairperson Dutch Safety Board

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Secretary Director

1 INTRODUCTION

1.1 The occurrence

On the evening of 20 April 2022, the chemical tanker NCC SAFA sailing under the flag of Saudi Arabia was anchored at the anchorage 8 of the coast of IJmuiden, in the North Sea (within the twelve mile zone). The recently unloaded vessel had discharged its cargo of palm oil in Rotterdam, and was being prepared to take on a new cargo of gas oil in Amsterdam. To receive the new cargo, the tanks first had to be filled with inert gas (nitrogen, N_2). In accordance with the procedure the tanks had to undergo a final visual inspection after washing, before they were filled with this inert gas.

At around 19.00 hours (LT), an able-bodied seaman (AB) carried out this final visual inspection in the front tanks, before they could be filled with the nitrogen. When the captain tried to make contact with the AB on the walkie-talkie, he received no reply. Thereupon he sent the first officer to the front tank to investigate the situation. Upon arrival, the first officer saw the AB lying on a platform in the tank and sounded the alarm via the walkie-talkie. This was the only contact between the first officer and the other crew members on board the vessel. When the captain arrived at the tank opening, he too saw the AB lying on a platform in the tank. The AB was retrieved from the tank by the vessel's rescue team and with serious injuries subsequently transported to hospital in Alkmaar (NL) by SAR helicopter. The first officer was found on the bottom of the tank. Resuscitation efforts were started, but proved unsuccessful.

1.2 Classification

The incident has been classified as a 'very serious' accident as defined in the Casualty Investigation Code of the International Maritime Organization (IMO) and Directive 2009/18/EC of the European Parliament and Council. This means that as coastal state, the Netherlands has the authority to investigate the accident. The option to carry out an investigation in this case is also laid down in the Dutch Safety Board Decree. It was agreed with Saudi Arabia, the flag state of the vessel, that the Dutch Safety Board would lead the investigation because the accident occurred in Dutch waters. Saudi Arabia participated in the investigation as state with a substantial interest.

1.3 Purpose of the investigation

The purpose of this investigation is to answer the following investigation questions:

- How could this accident happen in the enclosed space of the tank on board the vessel?
- Was the safety risk that arises when entering an enclosed space recognized as such by the crew?
- What lessons can tanker operators, crews and the authorities concerned learn from this accident?

1.4 The investigation

The investigation started one day after the accident, on 21 April 2022. Investigators of the Dutch Safety Board boarded the vessel in Amsterdam. They interviewed the relevant crew members, gathered documentation and conducted a technical investigation. The national and Maritime Police and a coroner were present on board, as well as representatives of the shipping company and the Human Environment and Transport Inspectorate (ILT). The investigators of the Dutch Safety Board requested further information and interviewed the injured victim at a later date. The available data was analysed.

2 BACKGROUND INFORMATION AND COURSE OF EVENTS

2.1 Background information

The vessel

The NCC SAFA is a 183-metre-long oil and chemical tanker. The tanker was built in 2011 at the Shinasb yard in Tongyoung, South Korea. The vessel sails under the Saudi Arabian flag. The vessel is managed by Mideast Ship Management. This shipping company was founded in 1978 in Saudi Arabia and manages a fleet of 93 oil and chemical tankers, bulk carriers and multipurpose vessels.

The crew

At the time of the accident, the vessel had 24 crew members on board, from eight different nationalities.

Table 1: Positions and nationalities of crew members of the NCC SAFA

	Position	Nationality
1	Captain	Indian
2	First officer (deceased victim)	Indian
3	Second officer	Russian
4	Third officer	Ukrainian
5	Third officer	Croatian
6	Chief Engineer	Russian
7	Second Engineer	Rumanian
8	Second Engineer	Rumanian
9	Third Engineer	Indian
10	Fourth Engineer	Georgian
11	Electrical Engineering Officer	Russian
12	Pumpman	Filipino
13	Boatswain	Filipino
14	Able Body 1 (AB)	Filipino

	Position	Nationality
15	Able Body 2 (AB) (injured victim)	Filipino
16	Able Body 3 (AB)	Filipino
17	Ordinary seaman 1 (OS)	Filipino
18	Ordinary seaman 2 (OS)	Filipino
19	Fitter	Filipino
20	Oil man	Filipino
21	Oil man	Filipino
22	Cook	Filipino
23	Assistant cook	Filipino
24	Trainee	Jordanian

Many lower-ranked crew members receive on-the-job practical training on board the tanker. New crew members start with the rank ordinary seaman (OS), advancing to the rank of able bodied seaman (AB) and subsequently to for example pumpman. From the start, they accompany and learn from experienced colleagues.

2.2 Course of events

On the evening of 20 April 2022, the chemical tanker NCC SAFA was anchored at anchorage 8 of the coast of IJmuiden (within the twelve mile zone). The vessel had discharged palm oil in Rotterdam on 12 April, and was being prepared to take on a new cargo of gas oil in Amsterdam. This required the tanks to be cleaned. Following the unloading and prewashing of the tanks, an inspection was carried out by a specialist company in the Port of Rotterdam. The vessel then departed for open sea to complete the cleaning of the tanks outside the Sulphur Emission Control Area.[1] On 19 April, the vessel arrived at anchorage 8 of IJmuiden to continue preparing the tanks for the new cargo, to be loaded in Amsterdam.

To take in the new cargo, the tanks had to be filled with inert gas (nitrogen, N_2) to prevent the risk of ignition or explosion. Before the tanks were filled with this inert gas in accordance with the procedure, they first had to undergo a final visual inspection. The purpose of this inspection was to determine that after cleaning no material, such as a dirty cloth or walkie-talkie, had been left behind in the tanks. The rear tanks were then prepared and filled with nitrogen until the oxygen level in the tank was below 8 vol%. The front tanks were prepared one day later.

1 According to MARPOL Annex VI, the North Sea is a so-called Sulphur Emission Control Area (SECA). This is a sea area subject to stricter controls aimed at minimizing emissions into the air by ships.

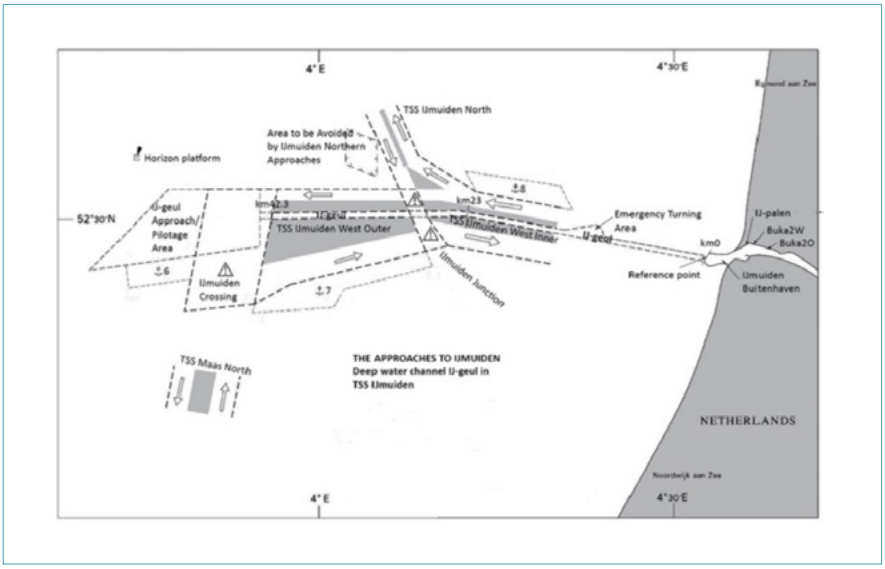

Figure 1: IJmuiden approaches, anchorage 8.

On 20 April, on the instructions of the captain, the AB went to inspect the front cargo tanks. Two days previously, the crew members had completed the final cleaning in the tanks, so that only the final inspection had to be carried out. Because no peculiarities had been observed during the cleaning two days earlier, the issuing of an Entry Permit[2] for the final inspection, the use of a personal gas meter and the posting of a second person at the tank opening, as laid down in the procedure, were not considered necessary by the crew, and the procedure was therefore not followed by the AB. The AB was wearing the other personal protective equipment such as a helmet, work shoes, overalls and gloves.

At around 19.00 hours (LT), the AB was carrying out the final visual inspection of the front tanks. He first checked tank number 1 on the port side (1P) which involved descending to the first platform in the tank, so that he could thoroughly inspect the entire tank. He then went to tank number 1 on the starboard side (1S). This tank features four platforms linked by permanent ladders and is 18 metres deep (see figure 3). The AB also descended to the first platform, in tank 1S. From that platform, using a torch, it was possible to see whether the tank was completely empty and clean. During the descent, the AB felt dizzy and lost consciousness. He fell and landed on the second platform. As a result of the fall, he suffered serious injuries.

When the captain called the AB via the walkie-talkie to ask about the status of his work, he was unable to make contact with the AB. Also using the walkie-talkie, the captain then asked the first officer to check on the AB. When the first officer arrived at tank 1S, he immediately requested assistance via the walkie-talkie. The captain heard this call for assistance from the first officer, and made his way to the tank. There was no further contact with the first officer.

2 For more information see the blue box 'Procedure for entering enclosed spaces' on page 21.

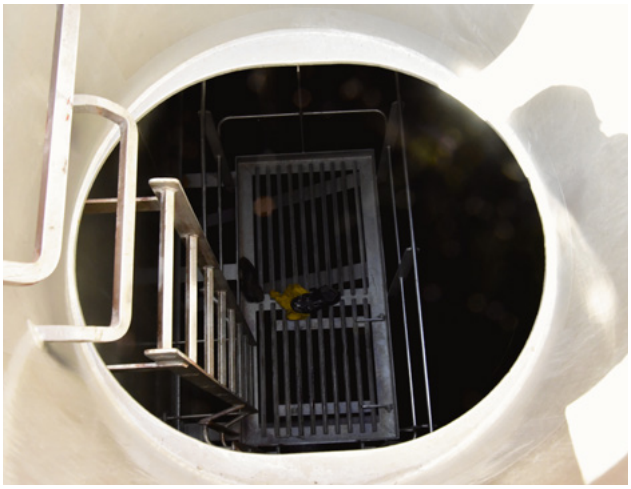

Figure 2: Top view of tank with view of the first platform.

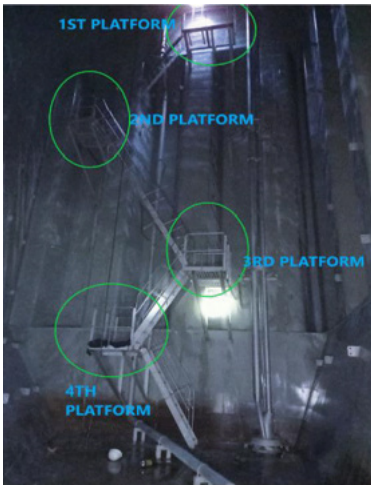

Figure 3: Inside of tank 1S.
(Source: Mideast Ship Management)

The captain reached the tank opening and looked in from above. He saw the AB lying on the second platform in the tank and immediately sounded the alarm. The rescue team, made up of crew members from the vessel, immediately entered the tank equipped with the appropriate rescue gear. The AB was carried onto the deck by the rescue team, where oxygen was administered. He was subsequently transported to hospital in Alkmaar (NL) by SAR helicopter. On arrival, he was admitted to intensive care with serious injuries.

The first officer was discovered at the bottom of the tank on the fourth and final platform, from where he was carried to the ship's deck by the rescue team. Investigation revealed that the first officer had probably entered the tank after the AB and, just like the AB, had become unwell due to a lack of oxygen. As a result, he fell into the 18-metre-deep tank. As a result of the fall, he suffered such severe injuries that the attempts to resuscitate him, on location, proved unsuccessful.

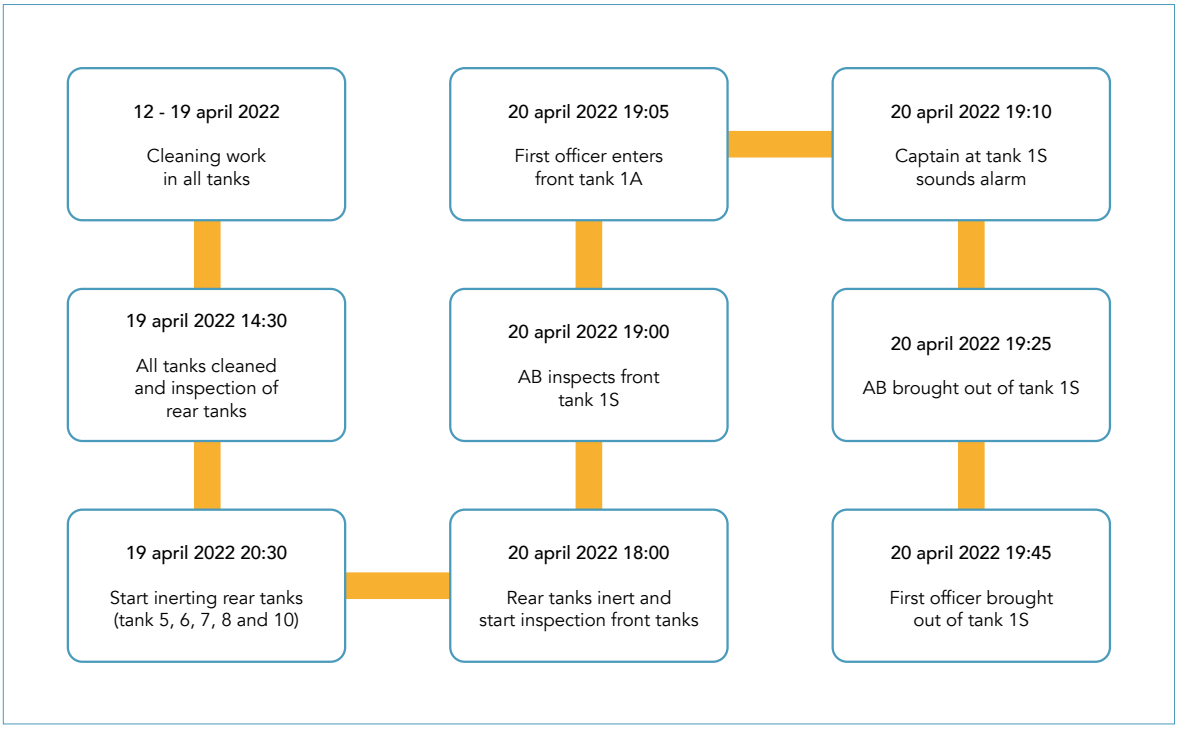

Figure 4: Timetable for the course of the incident.

3 ANALYSIS

The National Institute for Public Health and the Environment (RIVM) has identified three commonly occurring causes of accidents in an enclosed space. In accidents in an enclosed space, it has been determined that in 56% of all cases, the cause was a failure to detect hazardous substances in the atmosphere. In more than one-third (39%) of accidents, the cause was a failure to prevent hazardous substances from entering the space. Finally, in 32% of all accidents, the victims were not equipped with the correct personal protective equipment such as a gas meter.[3]

The analysis of the incident on board the NCC SAFA considers various aspects that played a role, including consideration of the three points identified by RIVM. Based on this analysis, the investigation looked into the direct causes, failing safety barriers, circumstances and underlying causes that contributed to the fatal accident on board the tanker.

3.1 Direct and underlying causes

The direct cause of the occurrence is that the two crew members became unwell due to a lack of oxygen. This lack of oxygen caused the AB to lose consciousness and fall onto the second platform. In the case of the first officer, the lack of oxygen led to loss of consciousness and a fatal fall onto the fourth platform in the tank. The cause of this lack of oxygen is further explained in section 3.2.

Section 3.3 considers in more detail the underlying causes. This section considers compliance with procedures for loading and unloading, safety and training, entering enclosed spaces and the wearing of personal protective equipment. A number of aspects relating to behaviour that could have contributed to the occurrence have also been identified.

3.2 Cause of the lack of oxygen

The direct cause of the occurrence was a lack of oxygen in the enclosed space of tank 1S, which caused two crew members to become unwell.

Use of inert gas

Rendering cargo tanks inert is carried out to prevent the occurrence of flammable gas mixtures in the cargo tanks and to avoid creating an explosive atmosphere inside the

3 https://www.rivm.nl/veilig-werken/informatie-over-ongevallen/besloten-ruimte/feiten-en-cijfers

tanks. The aim of introducing inert gas into a tank is to lower the oxygen level because oxygen is needed for ignition. On board the NCC SAFA, nitrogen is used and produced by a permanent inert gas system. Using this inert gas, the atmosphere inside the cargo tanks of the vessel can be monitored and maintained. Gas oil, the new cargo for which the tanker was being prepared, is unable to ignite in an atmosphere that contains less than 11 vol%[4] oxygen. Keeping the oxygen level below this percentage offers protection against fire or explosion. Generally speaking, 8 vol% oxygen is therefore maintained as a safe value. These values are achieved on board by filling the cargo tanks with inert gas via permanent pipelines, thereby ensuring the tank atmosphere is non-flammable.

Nitrogen (N_2)
A gas like nitrogen (N_2) is commonly used as an inert gas on board, because this gas can be easily produced by the vessel itself. Nitrogen is a non-toxic, non-flammable, odourless, colourless and tasteless gas, that is present all around us. Air is a mixture that consists of approx. 78 vol% nitrogen, 21 vol% oxygen and 1 vol% noble gases and between 0.1 and 4 vol% water vapour. This means that the presence of a large volume of nitrogen does not result in any direct warning to humans. For that reason, nitrogen is considered an insidious threat. As nitrogen is pumped into an enclosed space as an inert gas, the oxygen level will gradually fall. Entering an enclosed space of this kind can in that case quickly result in asphyxiation.

The valve

The inert gas (the nitrogen) on board the tanker is produced in the engine room, and production is supervised and operated from the cargo control room. Using two pumps, the inert gas is pumped through a central pipeline that runs from the rear of the vessel to the front, with a branch to each individual cargo tank. After each branch, a butterfly valve is fitted, which can be manually opened and closed by the crew members. When a valve is opened or closed, the cargo control room is duly notified by the crew member, via the walkie-talkie. On a marker board in the control room, the colour of the indicator is then manually changed, making it possible to see which valves are open and which are closed. Figure 5 shows the position of the valves on the marker board on the day following the accident. The red ring indicates that the inert gas valve to tank 1S is closed. This matches the information obtained during the various interviews. There is no other signal or marker that indicates whether the valves in this system are open or closed, or whether there is inert gas in the pipelines.

4 The volume percentage (abbreviated to vol%) is a measurement for the concentration of a substance in a mixture. It is the ratio of the volume of the substance as compared with the total volume, expressed as a percentage.

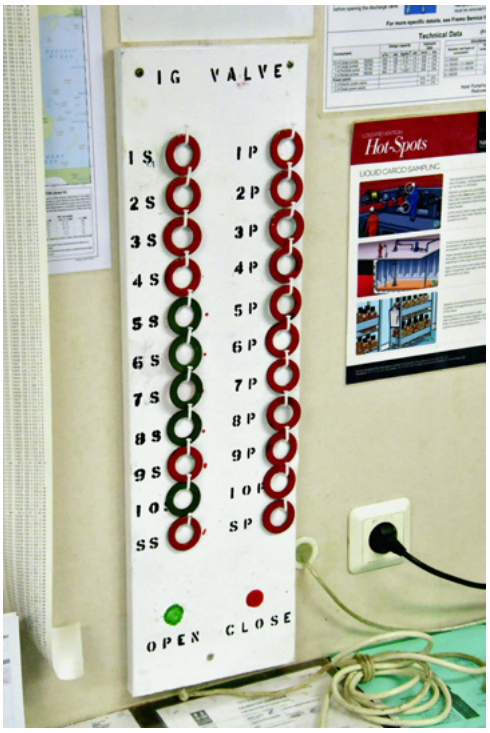

Figure 5: Marker board inert gas valves.

Two days after the incident, the inert gas valve was removed from tank 1S for inspection. The investigation revealed that this valve no longer closed correctly, while it appeared to be fully closed off. Due to damage to the worm gear (see figure 7), the disk remained open after closing, leaving a gap of approximately one centimetre.

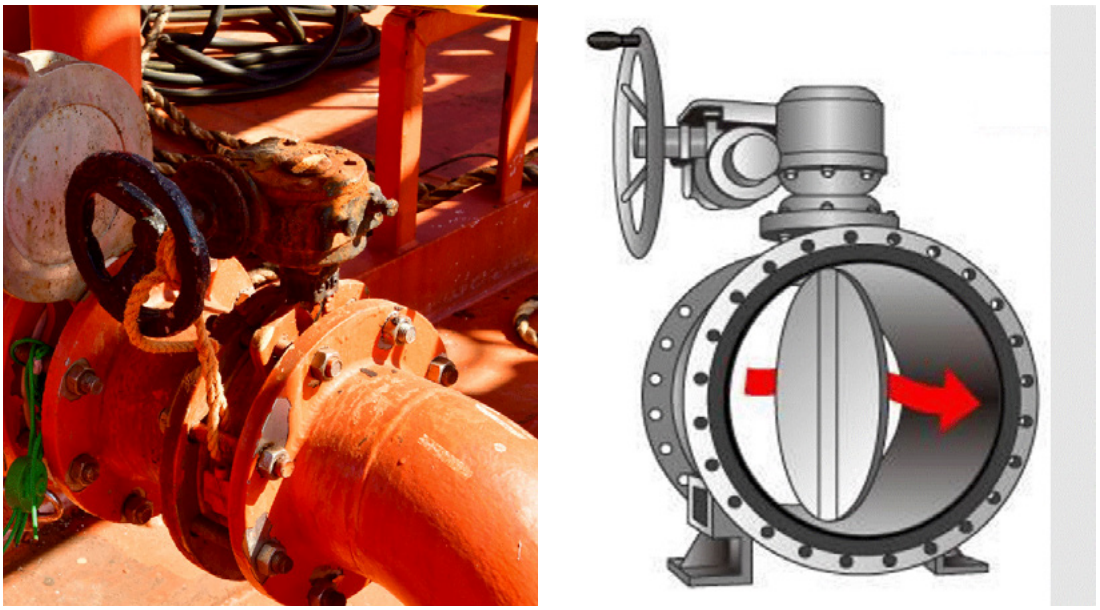

Figure 6: Valve in original position on board and illustration of the inner workings of the butterfly valve.

Figure 7: On the left, damaged worm gear, and on the right the disk still open in closed position.

The leaking valve allowed the nitrogen with which the front tank was being filled at the time of the incident to unintentionally also enter tank 1S. The preparation of the tanks for the new cargo by filling them with inert gas, had been started one day prior to the incident. As a result, the concentration of oxygen in tank 1S was also gradually reduced. An oxygen concentration of between 19 vol% and 21 vol% is safe. In an atmosphere with less than 19 vol%, there is a lack of oxygen, and at less than 18 vol% oxygen, the oxygen level is insufficient (see table 2).

Table 2: Effects and symptoms of oxygen level

Oxygen level	Effects and symptoms
21 vol%	Normal breathing
18 vol%	Decline in vision, a flame extinguishes
12-17 vol%	Confusion, reduced attention and coordination, shortness of breath, increased heart rate
11-14 vol%	No longer able to think, failure to recognize danger; sleepiness and fainting
8-11 vol%	Fainting without warning, nausea, inability to stand or crawl, indifference
0-8 vol%	Immediate loss of consciousness, coma

When the vessel rescue team (with the correct personal protective equipment), entered the tank during the rescue operation of the two crewmembers, their gas meter issued an alarm indicating a lack of oxygen. On the next day (21 April), 18.9 vol% was measured in the tank. This supports the assumption that at the time of the incident, the oxygen concentration was too low.

Gas meters

There are two types of portable gas meter on board the tanker. Six personal combined gas meters (O_2, H_2S, CO and LEL[5]) that can be worn on the body, and two multi gas meters that make it possible to measure the atmosphere in the tank from the outside, using a gas sampling hose and probe. The first officer is responsible for calibration of these portable instruments, once every six months.

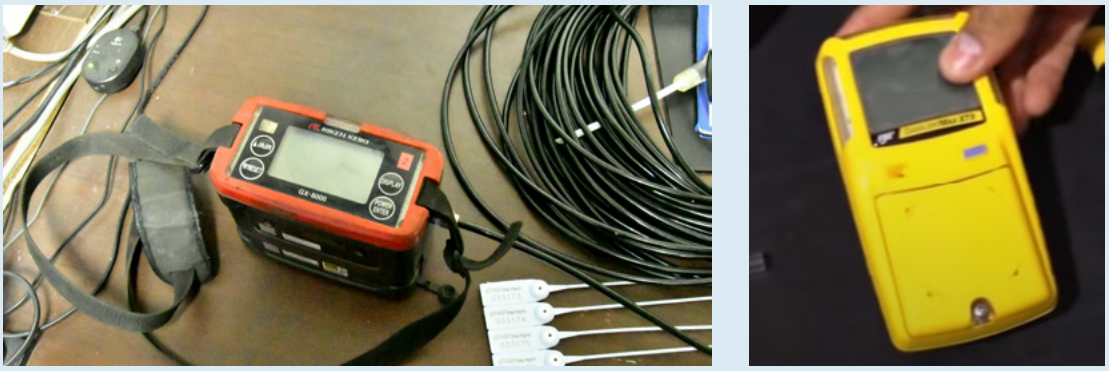

Figure 8: photograph left multi gas meter, photograph right personal combined gas meter.

The operating principle must be that work in the tanks can be carried out safely. On board the NCC SAFA, at the time of the incident, the only physical barrier between the inert gas pipeline system and the tank was a single valve. In this occurrence, the valve was found to be leaking, allowing nitrogen to flow into the tank, where one of the crew members was working at the time. No use was made of other separation methods, with which the pipeline could be temporarily, safely and fully sealed off, such as a blind flange.

- The (leaking) valve was the only barrier between the pipelines filled with inert gas and tank 1S.
- The failure of the valve made it possible for inert gas to enter tank 1S.
- The closing of the valves and the inspection are carried out manually, without actually inspecting the gas flow.

Maintenance protocol

The crew on board the vessel use computer software for planned maintenance (a planned maintenance system, PMS). This system specifies when, according to the schedule, a part must be maintained. Every three months, the functioning of the valves was checked by the crew, and the valves were lubricated according to the maintenance protocol. The only required maintenance in the maintenance protocol for the valves was a visual inspection, opening, closing and lubrication of the valves. There were no guidelines or agreements for further maintenance or overhaul of the valves. Inspection and lubrication were carried out from the top, by opening the cover. However, during this inspection, the deeper inner workings could not be examined.

5 Lowest Explosive Limit.

During the five-yearly vessel inspection in dry dock, the valves are not separately checked. Even then, the standard maintenance protocol remains in force. During this five-yearly inspection, the list of parts to be repaired according to the PMS is examined.

The checking and maintenance of a valve is part of the pump man's regular work. The pump man also assists during the cleaning of the tank, loading and unloading operations and other maintenance work. The pump man on board this tanker had been responsible for this work on various vessels and had several years' experience.

The maintenance report shows that on 12 March 2022, routine maintenance was carried out on the pipelines and valves. The valve that caused the accident was checked for free movement, visually inspected for corrosion and was lubricated. No other maintenance points are listed for this planned maintenance inspection. No peculiarities were observed, and the condition of the valve was reported as in order. When the valve was disassembled two days after the incident, remainders of lubricating grease were observed, confirming that the scheduled maintenance had been carried out. The pump man suggested that to his knowledge, this valve was functioning correctly at that time. The pump man had observed no physical damage or deformation to the valve during previous maintenance inspections. It should be noted that the functioning of the valve in the seat or damage to the worm gear cannot always be observed in an inspection from above and a check of the free movement of the hand wheel.

The safety of the crew and protection against hazardous gas mixtures caused by an inert gas system are dependent on the correct functioning and maintenance of the entire system. It is above all important to ensure that valves are functioning correctly. The maintenance protocol followed on board was limited to a visual inspection of part of the valve, as a result of which the damage to the worm gear went unnoticed.

The use of an inert gas system on board tankers calls for considerable caution. The safety management system (SMS) specifies that before the system is started, the status of the alarm and the indication, the correct functioning and the correct order of all related equipment must be checked and found to be in order. For the crew, the system on board the tanker appeared to be in order, but the limitations in the prescribed inspection and maintenance of the pipelines and valves of the inert gas system meant that the damage inside the valve, which led to the leak, remained unnoticed.

- The limited maintenance protocol consisted of lubrication and a visual inspection of the free movement of the hand wheel, which meant that the damaged internal part of the valve went unnoticed.
- Safety-critical components such as valves were not subject to a structural overhaul cycle.

3.3 Procedures

Loading and unloading procedure

Loading and unloading procedure
The shipping company loading manual specifies that the captain is responsible for the entire loading and unloading operation on the vessel. The captain receives journey instructions from the charterers, and ensures that the ship is prepared for discharging or taking cargo on board.

After receiving the journey instructions, the first officer draws up a loading plan, using the forms supplied by the shipping company. A separate plan must be drawn up for every loading and unloading location. The captain checks these plans and sends them to the charterer for approval. One essential element in drawing up a cargo plan is preparing the tanks for loading. Attention must be paid to the degree of cleanliness required and whether a coating has to be applied. The stowage plan, an integral part of the loading plan, includes among others the order in which the tanks are to be loaded and shows the position and status of the valves to be opened/closed.

The captain checks the loading plan prepared by the first officer and communicates the content to the officers on board. They must confirm the plan by applying a signature. The captain then sends a copy to the shipping company. The first officer carries out the procedure to prepare for loading. This includes ordering the completion of such tasks as cleaning and inspecting the cargo tanks including the inspection for loose objects such as cloths, nuts and bolts in the tanks. He is also required to order or carry out the inspection for leaks and check the meters for correct functioning.

According to the documentation, the tanker was unloaded and stripped in Rotterdam, in accordance with the procedures from the Procedures & Arrangements Manual (P&A)[6]. On 12 April 2022, the vessel then set sail for open sea to continue cleaning all tanks outside the Sulphur Emission Control Area. This final cleaning process involved mopping out the front tanks. The cleaning of the tanks continued until the afternoon of 19 April, at which point the vessel anchored off IJmuiden. At 14.30 hours (LT), all tanks had been cleaned and ventilated. That evening, following a final inspection, a start was made on making the group of tanks at the rear (5, 6, 7, 8 and 10) inert. This process took until 18.00 hours next day (20 April). During the course of this process, under the supervision of the first officer, the trainee was involved in regularly measuring the oxygen level in the rear tanks.

6 MARPOL annex II requires that every vessel certified for the transport of dangerous liquids in bulk, is in possession of a Procedures & Arrangements Manual (P&A).

At 18.00 hours, a start was made on making the front tanks ready for filling with inert gas. The AB carried out the final check. The AB had received the order directly from the captain, while according to the procedure, the first officer is responsible for and is in charge of the tank cleaning and all preparations for the new cargo. The procedure also states that no cargo tank whatsoever may be entered during the process of inerting another cargo tank. At the time the AB received the order from the captain, the first officer was present at the manifold, and not near the entrance to tank 1S, where the AB carried out the final check.

The vessel had been given a time window (laycan[7]) of between 18 and 20 April 2022, the timeframe within which the vessel had to be presented at the agreed port. If the vessel arrives after the final day of the laycan, the charterers are entitled to refuse the vessel and to cancel the charter. The captain subsequently stated that he had decided to deviate from the procedure because of the perceived time pressure as a result of the issued laycan. Moreover, no work plan was prepared for the tank cleaning, or for inerting the tanks, which meant he had no clear overview.

- The order was issued directly to the AB by the captain. According to the procedure however, the first officer is in charge during loading/unloading and all preparation work.
- The first officer was not in the vicinity of tank 1S, because he was carrying out work in another part of the vessel, together with the trainee.
- The captain indicated that his actions were dictated by a sense of time pressure as a result of the issued laycan.

7 Laycan is an abbreviation for 'Laydays and Cancelling Date'. This clause defines the time window within which charterers are required to accept the vessel in the loading port.

Procedure for entering enclosed spaces

Procedure for entering enclosed spaces

The procedure for entering an enclosed space on board the vessel is laid down in the vessel's Safety Management System (SMS). The underlying principle is that a space must be considered hazardous until it has been determined that it can be entered safely, and that entry is only permitted if all appropriate safety measures have been taken. According to this procedure, it is forbidden to enter any tank during the process of rinsing or inerting one or more (other) tanks. In the risk inventory & evaluation (RI&E) that must be carried out at the start of work in an enclosed space, attention is also paid to possible rescue operations. If all conditions are satisfied, an Entry Permit is issued. This Entry Permit is valid for a specific location and for a specific duration. In addition, a logbook must be kept (on the bridge) containing a record of every person entering an enclosed space.

To prepare for work in an enclosed space, the crew members in question first read the work plan and discuss the risks of entering a tank, according to a checklist. Everyone who is to enter the tank then signs the form to indicate that they understand the agreements on safe work. This is followed by the Entry Permit, granting permission to enter the tank. The Entry Permit also contains information about protective equipment that must be taken into the tank, which measurements must be taken and what medical and safety equipment must be in place. The Entry Permit is also signed by the captain, the person who draws up the permit (generally the first officer) and the watchman. The watchman is stationed at the tank opening to supervise the safety of the crew in the tank. The watchman is also responsible for communication with the bridge. Once the work is completed, the form is once again signed by the person who drew up the form.

Before entering the tank, the atmosphere must be checked with a gas meter (see the blue box on page 17). This measurement must be repeated at regular intervals. The time between two measurements may never exceed thirty minutes. Other work to be carried out at the same time must first be assessed for potential risks. Before entering a tank, a final toolbox meeting must be held with the persons involved, including a personal communication check. As long as someone is present in the tank, a black card must be suspended above the tank, as a visual indicator that someone is present in the tank.

Entering enclosed spaces is considered an essential operation on board the tanker. Because of the dangerous nature of the work, anyone entering an enclosed space is subject to a compulsory risk analysis and the issuing of an Entry Permit, as was the case on board the tanker on 18 April for the cleaning work in the six front tanks. The Entry Permit issued was valid on op 18 April 2022 between 18.30 hours and 00.00 hours and was signed by all persons involved, including the captain and the first officer.

The gas measurements at the time of the work indicated an oxygen level in all six tanks of 20.9 vol%. This Entry Permit was withdrawn at 20.30 hours because by that time the work had been completed. After that time, entry to the tanks was no longer permitted.

On 20 April, following the captain's orders, the AB entered the front tanks. No Entry Permit was issued on this occasion, and no one was present at the tank entrance where the AB descended to carry out the inspection.

Communication between crew members was via walkie-talkie. The walkie-talkies were switched to the same channel, but there was no agreement between the AB and the first officer. Only the captain, who had issued the order to the AB, and the AB had direct radio contact. At that moment, the captain was not on deck and failed to observe that the first officer and the trainee were located elsewhere, rather than accompanying the AB to tank 1S. It is well-known to the crew that due to the construction of the vessel, the walkie-talkies do not have good reception at all locations. This makes it necessary to issue a radio message check. It is therefore unclear whether the first officer was aware that the AB was entering the front tank.

According to the procedure, the duty officer or boatswain carries out a gas measurement in advance to check whether it is safe to enter the tank. When entering the tank, the AB expected no problems because previously (on 18 April), other crew members had already been in the tank to clean the tanks. He only needed to descend to the first platform from where he could inspect the tank with a torch, a task that did not require much time. On this occasion, before entering the tank, no check or gas measurement was carried out by the duty officer or the boatswain.

- The AB assumed that the tank was safe to enter on the basis of a previously issued Entry Permit. As a consequence, the procedures for entering an enclosed space were not followed. No risk analysis was carried out for the work of the AB in tank 1S, and no new Entry Permit was issued. No watchman was placed at the tank entrance.

Safety and training procedure

The safety drills and emergency procedures were regularly trained on board the tanker and recorded in the logbook. Two weeks prior to the incident, the entire crew had participated in a training session. The training session included both a practical and a theoretical component. The subjects were: the use of compressed air equipment, measuring the oxygen level in a tank, the use of the various gas meters and the operating procedure for enclosed spaces. For training purposes, videos are also available specifically about entering enclosed spaces. Entering the tanks in an emergency was also trained in practice. The training sessions were followed by an evaluation. The first officer is the safety officer responsible for training; the captain supervises the first officer.

Safety and training procedure
Requirements for training and safety equipment, among others, are described in the SOLAS[8] Convention. The safety equipment breaks down into firefighting equipment and liferafts, lifejackets and lifeboats. The convention specifies that certain safety exercises and emergency procedures must be trained at regular intervals.

After a crew member is signed on, the procedure specifies that a familiarization procedure must be organized. During this procedure, all safety rules and safety procedures are explained, including the procedure for entering enclosed spaces.

Posters containing safety rules and information are placed at various locations on board the vessel. In several interviews, the crew indicated that they were aware of the safety rules and agreements on entering enclosed spaces. Familiarization had been performed with the crew members and they all had a signed familiarization form.

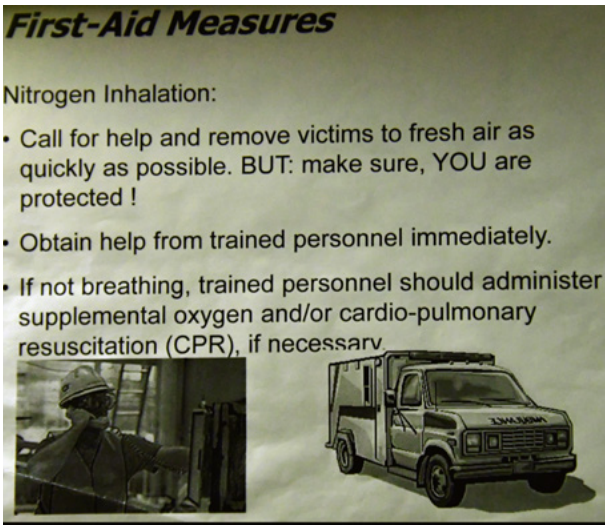

Figure 9: Example of safety information on board the NCC SAFA.

The safety management system on board the NCC SAFA is valid until 1 March 2026 and satisfied the requirements of the ISM code. The ship manager was also certified to conduct safety management on various vessel types such as bulk carriers, chemical tankers, oil tankers and other cargo vessels. The ship manager's safety certificate is valid until 19 November 2026.

8 *International Convention for the Safety of Life at Sea.*

- Safety information about entering enclosed spaces was available on board, and safety training sessions were held that cover safe working.

Use of Personal Protective Equipment (PPE)
According to the procedure on board, a personal gas meter must be carried on deck during loading, unloading and when working with inert gas. Six personal gas meters are available on board, for this purpose.

When entering the tank, the AB was wearing his personal protective equipment including a helmet, safety glasses, overalls, gloves and safety shoes. The AB was carrying a torch and walkie-talkie. He did not carry a personal gas meter because wearing a gas meter was not considered necessary in this case, as the tanks had already been measured for safe cleaning on 18 April, two days before the incident. However, standard procedure requires the tank to be measured before and during entry by the first officer or the boatswain. During the measurements on 18 April, other crew members had been able to enter the tank without problem. At that time, the entire procedure had been completed in accordance with the agreements, and an Entry Permit had been issued valid from 18 April 18.30 hours, for a maximum of 8 hours.

The first officer was also wearing his personal protective equipment and was carrying a walkie-talkie, but he too had no personal gas meter.

- Both the AB and the first officer entered the tank without a personal gas meter.

3.4 Human behaviour and helping behaviour

Within the professional group in question, it is generally well-known that entering enclosed spaces and inhaling low concentrations of oxygen are very dangerous. Crew members responsible for carrying out tasks in enclosed spaces receive specific training. Furthermore, it is required to carry out a risk assessment and to draw up an Entry Permit. Nonetheless, accidents still happen. A large proportion of the victims suffer problems because of an attempt to rescue someone from a space in which dangerous concentrations of gas are present. This was the case for the first officer, who tried to offer assistance. His attempt to rescue the AB led to his own fatal accident.

A literature study conducted by the Netherlands Organisation for Applied Scientific Research (TNO), commissioned by the Dutch Safety Board following a fatal accident in a manure silo[9], came up with the following possible explanations: 'helping behaviour is first and foremost a consequence of the fact that humans by nature have the tendency to offer assistance to someone in need'. This relates to such personality traits as empathy and helpfulness, but also learned social behaviour. In the maritime sector, these factors may even play a greater role because the crew of a ship are reliant on each other when they set sail, and live together for weeks if not months in a limited space.

Situation-specific factors such as the location or the number of bystanders also contribute to helping behaviour. In the case of the AB and the first officer, there was no other crew member in the vicinity who could offer immediate assistance, which probably increased the tendency of the first officer to take responsibility and offer assistance. Moreover, because of his familiarity with the work, it was probably immediately clear to the first officer that this was an acute emergency situation. This probably resulted in his perception of the urgent need to immediately do something about the situation and to follow the impulse to offer assistance.

The TNO literature study reveals that specific training and the supplying and sharing of information can have a major influence on impulsive helping behaviour. It is a very desirable trait to want to help others. However, it becomes a problem if the help giver places his own life in great danger. Additional training with a focus on human behaviour and the dangers and limitations of impulsive helping behaviour can result in better risk assessments.

In the past, risks at sea were above all managed with rules and regulations on technical matters. Ever stricter requirements were imposed on the vessel and its equipment. Technical solutions that make it physically impossible for the crew to work unsafely are not always available for every situation. It is becoming increasingly clear that incidents to a large extent are caused by human behaviour.

In order to successfully manage human behaviour, procedures in the field of desirable and undesirable behaviour can be extremely valuable. An advantage of procedures is that they contribute to the transfer of (new) knowledge as efficiently, as effectively and as unambiguously as possible. Procedures also provide everyone with clarity and guidance. In this respect, too, information provision and training can contribute to improved safety awareness.

- By nature, humans have the tendency to offer assistance to someone in need. This tendency can be amplified by various environmental factors. Specific training and information provision can help to prevent people placing themselves in mortal danger when they decide to help someone else.

9 https://www.onderzoeksraad.nl/nl/page/3015/dodelijk-ongeval-in-mestsilo-te-makkinga

4 CONCLUSIONS

The occurrence involved an inert gas system with only a single valve forming a hard safety barrier, a situation that is in principle unsafe and insufficient. This, in combination with the sense of time pressure and incorrect assumptions based on a previously issued Entry Permit that led the crew to not follow the procedures, made it possible for this occurrence, involving both the AB and the first officer, to take place.

Both the AB and the first officer became unwell due to a lack of oxygen after entering tank 1S. As a consequence, both crew members lost consciousness and fell onto a platform, situated below. The AB suffered serious injuries. The first officer lost his life.

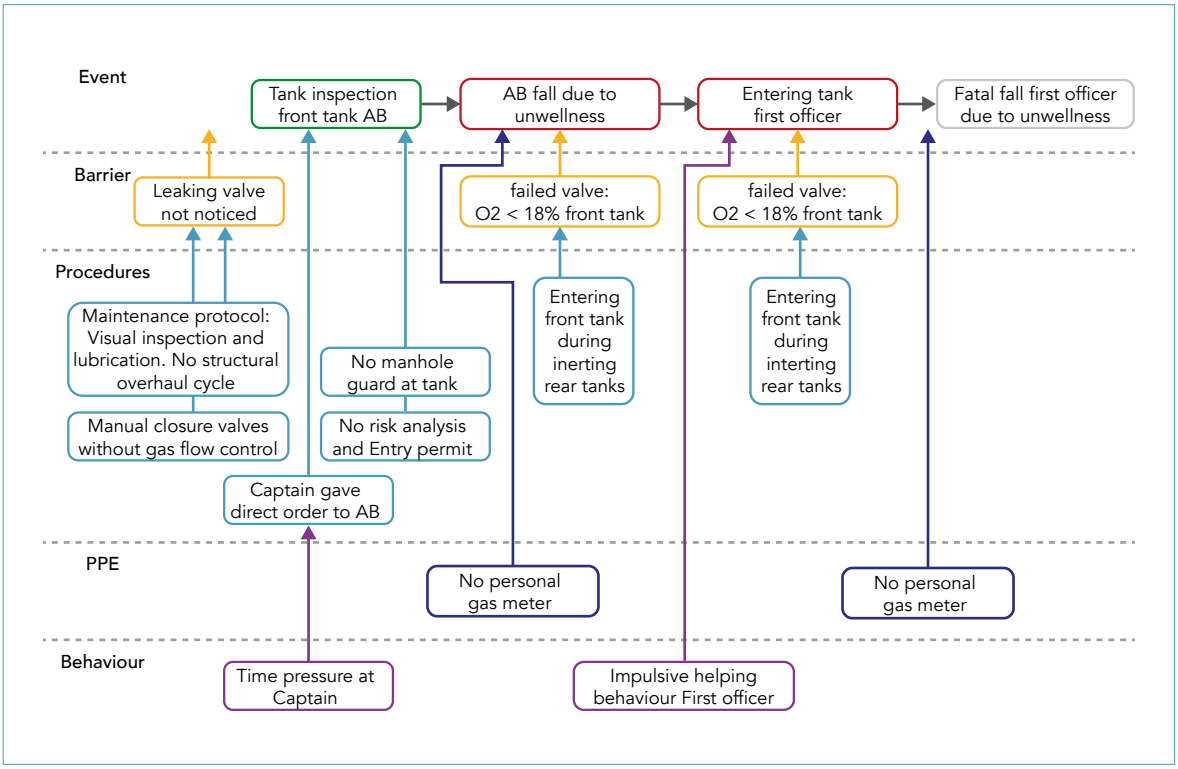

Figure 10: Diagrammatic representation of the cause and underlying factors.

The investigation reveals that the three causes identified by RIVM, as mentioned in chapter 3, also played a role in the incident on board the NCC SAFA. A leaking valve allowed nitrogen to enter tank 1S while inerting the aft cargo tanks on board. As a consequence the oxygen level in the tank 1S also fell. Despite being aware of the safety rules and the safety information available on board, the procedures were deviated from. The order to inspect the forward tanks was given without fulfilling the conditions. Prior to the inspection of tank 1S by the AB, no risk analysis and accompanying gas measurements were carried out, and no Entry Permit was issued. Moreover, although both the AB and the first officer were wearing their helmet, overall and safety shoes, neither was carrying a personal gas meter when they entered the tank.

5 RECOMMENDATION AND LESSONS

Based on the investigation of this incident on board the NCC SAFA, the principle 'follow the procedures' is once again underlined. In addition, the Dutch Safety Board comes to the following recommendation to the shipping company:

To Mideast Ship Management

1. Provide an inert gas system constructed so that there are multiple safety barriers. This should include a control system for the use of inert gas, whose capabilities and limitations are known to the entire crew.

In addition to the recommendation the following lessons can be learned from the incident:

1. During inspection and maintenance, the crew must be mindful of possible failure of the inert gas system due to damage. Ensure that all safety-critical components are identified and adjust the maintenance protocol accordingly. A maintenance protocol limited to only lubrication and visual inspection of part of a valve gives an unwarranted sense of being safe.

2. Crew should be able to speak up and stop work if another crew member (including the captain) does not follow a procedure. Provide a working environment where crew feel safe to do so.

3. Targeted training and education ensure that procedures can be followed and impulsive actions, where people put themselves in mortal danger, are prevented.

APPENDIX A

Vessel data	NCC SAFA
	
Call letters:	HZEI
IMO number:	9411329
Flag State:	Saudi Arabia
Home port:	Dammam (Saudi Arabia)
Type of ship:	Oil and chemical tanker
Classification society:	Bureau Veritas
Year of construction:	2011
Shipyard:	Shinasb yard, Tongyoung, South Korea
Overall length:	183 m
Breadth:	32 m
Gross Tonnage:	29168 t
Engines:	B&W 6S50MC
Maximum propulsion capacity:	9485 kW
Maximum speed:	12.5 kn

APPENDIX B

RESPONSES TO THE DRAFT REPORT

In accordance with the Dutch Safety Board Act, a draft version of this report was submitted to the parties involved for review. The following parties have been requested to check the report for any factual inaccuracies and ambiguities:

- Bahri Ship Management
- Maritime Accidents Investigation Bureau of Saudi Arabia

The responses received can be divided into the following categories:

- Corrections and factual inaccuracies, additional details and editorial comments that were adopted by the Dutch Safety Board (insofar as correct and relevant). The relevant passages were amended in the final report.
- Not adopted responses; the reason for this decision is explained in the table.

The responses received, as well as the way in which they were processed, are set out in a table that can be found on the Dutch Safety Board's website (www.safetyboard.nl).

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