Danish Maritime Accident Investigation Board

MARINE ACCIDENT REPORT
December 2014

SCORPIUS
Occupational accident on 8 May 2014

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Case number: 2014011309

Front page: Hatch at cargo tank CT6S on board SCORPIUS. **Source:** DMAIB.

The marine accident report is available from the webpage of the Danish Maritime Accident Investigation Board www.dmaib.com.

The Danish Maritime Accident Investigation Board

The Danish Maritime Accident Investigation Board is an independent unit under the Ministry of Business and Growth that carries out investigations as an impartial unit which is, organizationally and legally, independent of other parties. The board investigates maritime accidents and accidents to seafarers on Danish and Greenlandic merchant and fishing ships as well as accidents on foreign merchant ships in Danish and Greenlandic waters.

The Danish Maritime Accident Investigation Board investigates about 140 accidents annually. In case of very serious accidents, such as deaths and losses, or in case of other special circumstances, either a marine accident report or a summary report is published depending on the extent and complexity of the events.

The investigations

The investigations are carried out separate from the criminal investigation without having used legal evidence procedures and with no other basic aim than learning about accidents with the purpose of preventing future accidents. Consequently, any use of this report for other purposes may lead to erroneous or misleading interpretations.

Contents

1. SUMMARY

On 8 May 2014 at 1830, the chief officer on board the Danish flagged chemical/products tanker SCORPIUS was found lifeless on the bottom of a cargo tank during a tank cleaning operation.

Fifteen minutes earlier, the chief officer had been inspecting the ship's port side cargo tanks. He had checked each of the tanks visually by taking a few steps down the tank access ladder. At approx.1825, the chief officer stopped responding to radio calls. The crew started to search for him and found him at the bottom of a starboard side cargo tank. The chief officer was evacuated immediately and provided with resuscitation treatment, but could not be rescued.

The marine accident report on this fatal accident centers on two topics: The construction and safety measures of the tank access ladders on SCORPIUS, and entering a tank without an entry permit.

In the report, The Danish Maritime Accident Investigation Board concludes that the fatal accident on SCORPIUS was a fall accident that connects to the ladder's design, and that the entry without a permit did not have an influence on the outcome of the accident. However, the DMAIB also discuss' the relation between safety procedures and operational workflow.

2. FACTUAL INFORMATION

2.1 Photo of the ship

Figure 1: SCORPIUS
Source: Sirius Shipping AB

2.2 Ship particulars

Name of vessel:	SCORPIUS
Type of vessel:	Chemical/products tanker
Nationality/flag:	Denmark
Port of registry:	Læsø
IMO number:	9318228
Call sign:	OXGJ2
DOC company:	Sirius Shipping AB
IMO company no. (DOC):	5385336
Year built:	2006
Shipyard/yard number:	Gisan Shipyard/36
Classification society:	Det Norske Veritas
Length overall:	129.75 m
Breadth overall:	19.88 m
Gross tonnage:	7,636
Deadweight:	11,249 t
Draught max.:	8.0 m
Engine rating:	4,320 kW
Service speed:	13.5 knots
Hull material:	Steel
Hull design:	Single hull

2.3 Voyage particulars

Port of departure:	Mongstad, Norway
Port of call:	Stigsnæs, Denmark
Type of voyage:	Merchant shipping, international
Cargo information:	Process water
Manning:	13
Pilot on board:	No
Number of passengers	0

2.4 Weather data

Wind – direction and speed:	NA
Wave height:	NA
Visibility:	Good
Light/dark:	Day light
Current:	NA

2.5 Marine casualty or incident information

Type of marine casualty/incident:	Accident to seafarer
IMO classification:	Very serious
Date, time:	8 May 2014 at 1820 LMT
Location:	Gulfhavn Oil Terminal, Port of Stigsnæs
Position:	55° 12.012' N – 11° 15.329' E
Ship's operation, voyage segment:	Alongside
Place on board:	Cargo tank
Human factor data:	Yes
Consequences:	One seafarer deceased

2.6 Shore authority involvement and emergency response

Involved parties:	Region Zealand medical services
Resources used:	One ambulance One medical car
Speed of response:	Approximately 10 minutes
Actions taken:	The injured person received resuscitation treatment ashore.
Results achieved:	The injured person was pronounced dead in the ambulance.

2.7 The relevant ship's crew

Master:	45 years old. Had served two years on board.
Chief officer:	43 years old. Had served eight years on board.
2nd officer:	41 years old. Had served one year on board.
Able seaman:	42 years old. Had served one year on board.
Able seaman:	44 years old. Had served two years on board.

2.8 Scene of the accident

Figure 2: Scene of the accident
Source: Google Maps

3. NARRATIVE

3.1 Background

At the time of the accident, the chemical tanker SCORPIUS was owned by the Swedish company Partsrederiet SCORPIUS and registered in the Danish International Register of Shipping. There were 13 crewmembers on board, and the crew consisted of three nationalities: Swedish, Finnish and Philipino. The official working language on board was English.

SCORPIUS was engaged in trade in the areas of the Baltic Sea, the Gulf of Bothnia and the North Sea. The ship did not have a regular voyage schedule, but was engaged in tramp trade. Usually, the voyages lasted between three days down to a couple of hours, and the ship had approx. 100 port calls per year.

The ship was specialized in carrying clean petroleum products and had a total cargo capacity of 12,394 m^3 in 12 cargo tanks.

3.2 Sequence of events

On 5 May 2014, SCORPIUS departed Mongstad, Norway, where it had been loaded with 10,496 t process water from Norwegian oil fields, and was bound for the Gulfhavn Oil Terminal at the Port of Stigsnæs, Denmark. The ship had carried this type of cargo between Mongstad and Stigsnæs before and, hence, was familiar with both ports and the handling of process water.

SCORPIUS came alongside at the Gulfhavn Oil Terminal on 7 May 2014. At 1500, the chief officer on board was relieved for vacation. The replacing chief officer was familiar with the ship and its operation, as he had served on board the ship since it was launched in 2006.

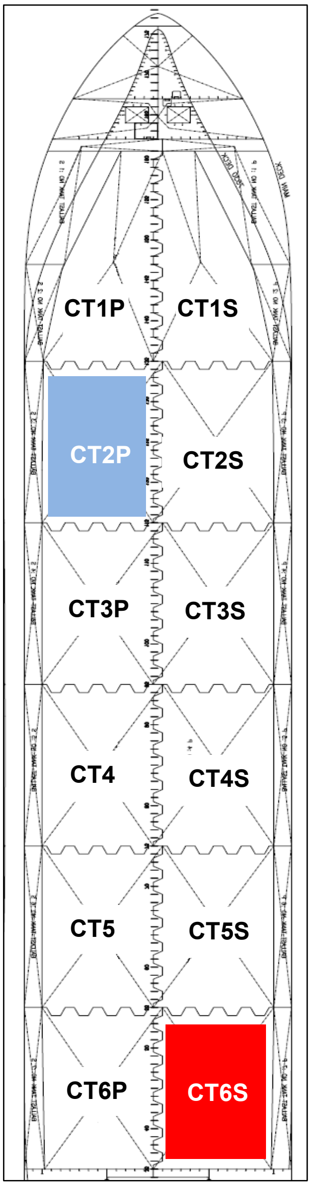
The following morning on 8 May 2014, the discharge operation was carried out and concluded around noon. Cleaning of the cargo tanks was to be initiated as soon as a surveyor from the terminal had confirmed that the tanks were empty. The surveyor was delayed and the master of SCORPIUS contacted the terminal several times and asked for the surveyor. He stressed that, if the surveyor was not on his way, then he would order the tank cleaning process started anyway.

The master had ordered a pilot for the next day at 0600 on 9 May 2014 and wanted to make sure that there was enough time to ventilate the tanks properly before departing the port. Therefore, he decided to initiate the tank cleaning before the surveyor had carried out the inspection. The cleaning of the tanks was estimated to take four and a half hours, and the master assessed that at least six to eight hours of ventilation was needed afterwards. The next port of call was Kalundborg with an estimated time of arrival of 0900.

The chief officer was in charge of the tank cleaning operation and was handing out orders to the 2nd officer in the control room and two ABs who were engaged in the tank cleaning on deck. One AB worked in the deck trunk, and the other AB was handling and monitoring the tank cleaning machinery on the tank deck. The chief officer's responsibility was to ensure that the tank cleaning was conducted in a safe manner and that the tanks were sufficiently cleaned.

Each tank was cleaned by means of two fixed tank washing machines, all Butterworth type machines. Initially, the tank bottoms were flushed with seawater, and then the tanks were cleaned full cycle with 50°C hot water and rinsed with fresh water.

The chief officer visually checked that the tanks were clean. On the day of the accident, he checked each of the tanks by taking a couple of steps down the tank access ladder and looking down the tank while lighting it up with a flashlight. While doing so, the chief officer did not wear a fall arrest.



Figures 3 and 4: Overview of the tank deck
Source: DMAIB

At 1802, the chief officer gave orders over the radio to start the cleaning of the penultimate cargo tank, no. 2 portside (CT2P) (figures 3 and 4). The AB on deck opened the water supply to the tank washing machines at CT2P. While he was monitoring the washing of the cargo tank, the AB saw the chief officer visually checking the port side cargo tanks and noticed him proceeding to the starboard side. The AB lost visual contact but reckoned that the chief officer was about to check the starboard side cargo tanks as well. As the ABs and the 2nd officer were busy carrying out their own tasks, none of them noticed whether or not the chief officer measured the levels of oxygen and toxic gasses in the tank atmosphere before he went on visually checking them.

At approx. 1815, the AB on deck noticed that his radio was running low on battery. He decided to go to the control room to change the battery before the cleaning of CT2P was concluded, as he needed to be ready for taking orders at the tank washing machine by then. While the AB on deck changed battery, the chief officer called out over the radio that he was going to check CT6S.

At approx. 1825, the 2nd officer informed over the radio that the cleaning of CT2P was almost finished and asked the chief officer for the next orders. He did not receive any reply. The 2nd officer tried to make contact with the chief officer several times over the radio without receiving an answer. He called out on the radio and asked the AB on deck to look for the chief officer at the tank. Because his radio was off when the chief officer called last time, he did not now at which tank to look, but was informed by the other AB in the tunnel to look at CT6S.

The AB went to CT6S and from the hatch opening he spotted the reflective striping on the chief officer's boiler suit at the bottom of the tank near the end of the ladder. At approx. 1830, the AB informed the 2nd officer that the chief officer was lying in the tank and that he was not moving. The 2nd officer went to the tank himself to confirm the AB's observation and then alarmed the master who was in his cabin.

The master hurried to CTS6 and ordered the crew on scene to fetch a stretcher, oxygen kit, and breathing apparatus. The master put on the breathing apparatus and entered the tank. He found the chief officer severely injured and unconscious. The master fastened a harness on the chief officer, and the crewmembers on deck hoisted him up. First aid was immediately initiated, and the 2nd officer contacted the terminal and asked them to call the emergency coordination centre. Meanwhile, the chief officer was fastened on a stretcher and hoisted over the side onto the quay by means of the ship's crane. The crew continued providing first aid ashore.

At approx. 1845, the ambulance arrived and the chief officer was brought inside and received resuscitation treatment. A medical car arrived at 1920 and ten minutes later, and the chief officer was pronounced dead.

3.3 The accident

The chief officer was found approx. one metre away from the foot of ladder on the port side (figure 5). The heating coils at the bottom of the tank, in the area where the chief officer was found, were significantly bent (figure 6). The bent heating coils and the nature of the chief officer's injuries suggest that he struck the bottom of the tank with great force. It is most likely that the chief officer fell from the uppermost part of the ladder, tumbled down some of the ladder´s steps, and fell over the left side handrails. The post mortem examination has established that the chief officer was killed by the impact of the fall.

Traces of benzene, toluene, and xylene were found in the chief officer's body. It is unknown whether these diesel oil and benzene components had been absorbed due to an acute or a long-term exposure, and the quantities are unknown, too. The chief officer's personal gas detector was found neither on him nor in the tank.

One hour after the chief officer had been evacuated, the master monitored the atmosphere in CT6S. The gas monitor went to its maximum of 100pp on the content of hydrogen sulphide (H_2S). The following day, it was proved that the atmosphere in all cargo tanks contained H_2S.

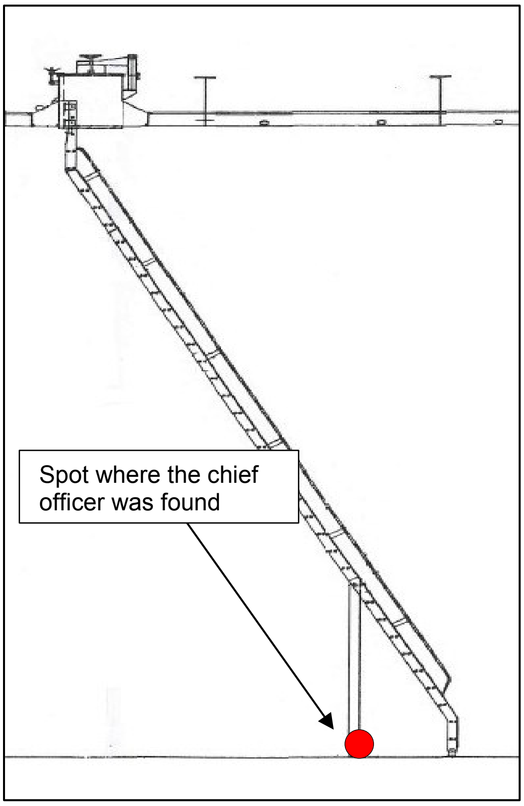


Figure 5: Scene of the accident, view
Source: DMAIB

Figure 6: Bent heating coils beside the ladder viewed from port side."
Source: DMAIB

3.4 Cargo tank access ladder

3.4.1 Design of ladder

Cargo tank CT6S was accessed through a hatch on the tank deck and by means of a permanent stainless steel ladder of 9.6 metres height. The ladder was vertical for one metre at the top, and then the inclination changed to approx. 60 degrees in relation to the horizontal plane surface (figure 6 and 7). For the last two steps of the ladder, the inclination changed to vertical again. The inclined part of the ladder was fitted with a handrail placed approx. 25 cm above the stringers, measured at a right angle of the stringers. The vertical top of the ladder was not fitted with handrails or back braces.

Between the stringers, the width was 40 cm, and each step consisted of two square bars of 22 mm by 22 mm in section fitted to form a horizontal tread with the edges of the bars pointing upwards. The distance between each tread was 25 cm.

Approx. 2 metres from the bottom, the handrails were found detached from their fittings on both sides of the stringers. The damage on the handrails may have occurred during the evacuation of the chief officer (figure 8).

The design of the tank access ladders on board SCORPIUS was surveyed and approved by the classification society and The Danish Maritime Authority.

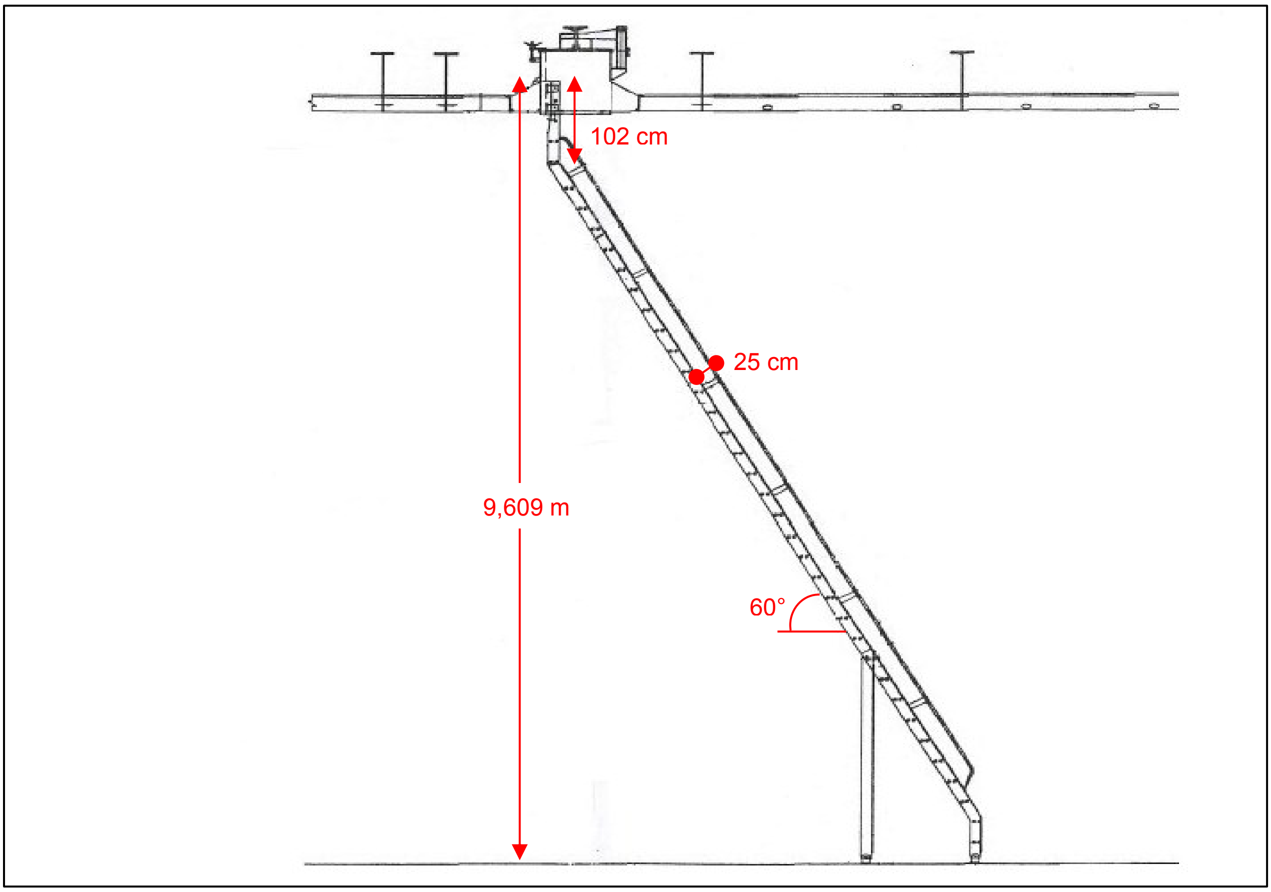


Figure 6: Drawing of tank access ladder on board SCORPIUS
Source: DMAIB/Sirius AB

Figure 7: Tank access ladder in CT6S
Source: DMAIB

Figure 8: Broken handrail
Source: DMAIB

3.4.2 Prevention of falls

Tank ladders are required to be constructed in accordance with the provisions of "*Notice B from the Danish Maritime Authority, Order on the construction and equipment, etc. of ships"* concerning prevention of falls. The ladder's height and inclination is determinant for which provision it applies to:

> *"In engine rooms, cargo tanks, cargo holds, pump rooms, storerooms and similar places, staircases and ladders between level differences of 2 m or more shall be designed in such a way that it is possible to pass from one level to the next completely safely. Thus, staircases and ladders shall have a suitable inclination, which shall be less than 70 degrees in relation to the horizontal plane, and which shall have railings along their entire length[1]."*

> *"Staircases or ladders with an inclination in relation to the horizontal plane of 70 degrees or more and with a height of more than 5 m above the deck or similar surface shall be provided with fittings to prevent falls when people pass between the levels. Such fittings shall, in the first instance, be either ladder hoops or arrangements for fall prevention equipment in the form or rails or wires[2]."*

The request for the ladder to be completely safe to climb is a description of intention and not a tangible, factual rule to comply with. Therefore, there are no specific requirements for the railings of the ladder.

The Danish Maritime Occupational Health Service's guideline on fall arrest measures describes that fall arrestors should be used when working on ladders more than 5 m high with an inclination that exceeds 70 degrees if the ladder is not fitted with back braces.

In the policy for safety and work environment on board from the ship's safety management system (SMS) it was stated that the crew was required to wear harnesses and make use of fall arrestors when working 2 meters above deck. It was, however, not common to use any fall arrest measures on board when entering the cargo tanks.

3.5 Tank cleaning procedure

According to the ship's SMS, the chief officer was responsible for deciding the temperature of the water used for cleaning, for how long each cargo tank was to be flushed with regards to the last and next cargo, and also for how long the tanks needed to be ventilated. As a guideline for the cleaning operation, the crew was instructed to use the company SMS procedure including an ISGOTT[3] flow chart (figure 9) and a Procedure & Arrangements manual complying with MARPOL 73/78 Annex II[4]. Furthermore, the crew could get access to online cleaning instructions for specific types of cargo via the ship owner management.

The tank cleaning procedure required that the crew filled in a form before initiating the operation stating the means of cleaning, amount of washing water to be used, the duration of the cleaning, and, if applicable, information on ventilation. The plan needed to be approved by the company management. Planning of cleaning operations was largely based on common practice and the crewmembers' routine and knowledge from experience.

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[1] Notice B, II-4, regulation 7.3
[2] Notice B, II-4, regulation 7.4
[3] International Safety Guide for Oil Tanker and Terminals
[4] International Convention for the Preventions of Pollution From Ships

The tank cleaning procedure in the SMS focused on the risk of explosion and intoxication and emphasized control of the tank atmosphere as being the most critical element in the tank cleaning operation. This predominant focus on atmosphere issues meant that the safety procedures did not cover and match the different situations of the operational workflow. The ISGOTT flow chart and the description of visual checks is an example of this.

The ISGOTT flow chart, which the crew was instructed to use, referred only to prevention of explosion and advised the crew on how to prevent this hazard by ongoing atmosphere testing and by stopping and starting the tank wash accordingly. It did not help the crew in planning the cleaning operation ahead or ensuring the quality of the tank cleaning. Furthermore, the ISGOTT flow chart was closed circuited and, hence, not useful in an operational situation; if the flow chart guideline was actually followed, the tank cleaning would be unending.

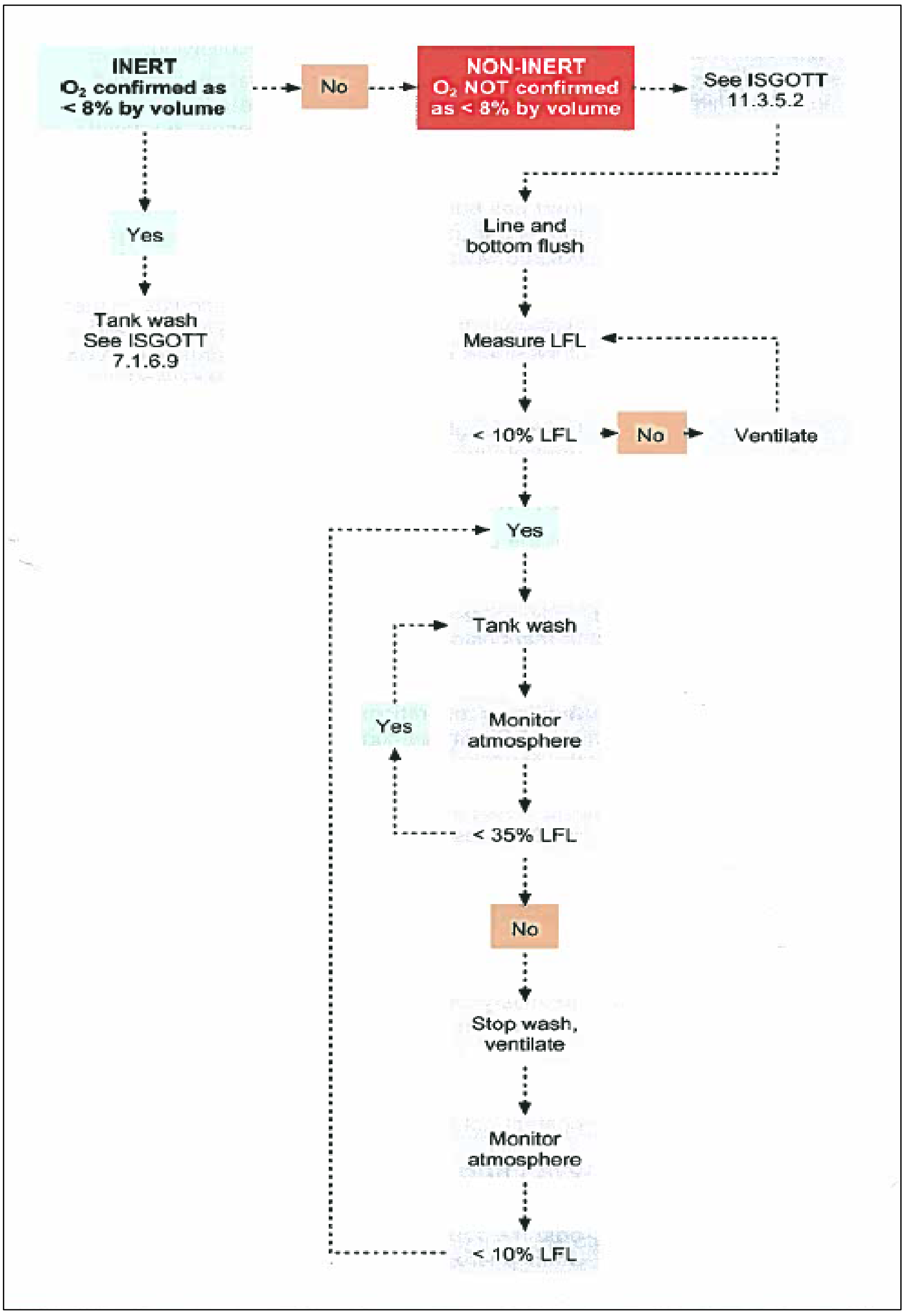

Figure 9: ISGOTT tank cleaning flow chart
Source: ISGOTT

If the tanks were not inert, the chief officer inspected the tanks visually between tank cleaning and ventilation to make sure, they were sufficiently clean. The SMS mentioned that the person carrying out the visual inspection should take care not to inhale vapours when inspecting the tanks that had not been gas freed and that the hatch was not allowed to be opened until the atmosphere test results showed <1% LFL[5] and < TLV-STEL[6] for toxic gas. When, how and why the visual checking was to be carried out was not described.

3.6 Entry into enclosed space

In the ship's SMS manual, the main hazard when entering enclosed spaces was described as being the risk of intoxication and lack of oxygen. In order to prevent enclosed space accidents, no crewmember was allowed to enter an enclosed space without an entry permit. The safety procedure of the entry permit covered the matters of personal protective equipment, the crewmember's responsibility, and monitoring of the atmosphere.

The entry permit was completed in a computer software system by a *responsible officer*, who could be the master, chief officer or chief engineer. It consisted of a check list and an entry log. The responsible officer issuing the permit was not allowed to be included in the team entering the enclosed space. The permit was to be signed by a *responsible person* and a *team leader* of the persons entering the enclosed space. The responsible person meant a crewmember appointed by the responsible officer, who was to be posted at the entrance of the enclosed space during the entire operation and was to be in direct contact with the responsible officer. The responsible person was to check that the crewmembers entering the enclosed space had the appropriate personal protective equipment and gas monitors, and that only persons signing the entry log entered the enclosed space.

When entering a tank, it was not common for the crewmembers on board to make use of harness and fall arrestor, as the ladder was considered safe. The entry permit check list required the persons entering an enclosed space to wear a harness in case of the need to facilitate a rescue operation. In a previous entry permit, the request of the harness was commented as "not applicable" by reference to the risk assessment sheet. The risk assessment identified the hazard of the enclosed space operation to be a low to medium risk of intoxication and lack of oxygen. No other hazards were identified in the risk assessment sheet.

3.7 Toxic substances in cargo

3.7.1 Material Safety Data Sheet

The material safety data sheet (MSDS) available on board for the actual cargo was a generic document on process water from the Norwegian offshore installations TROLL B/C, FRAM and KVITEBJØRN issued in 2010 and, hence, not prepared for this particular loading. The cargo was not classified as hazardous.

The product was composed of water (99 %), methanol (0.15 %) benzene (0.0009 %), toluene (0.0002 %), ethyl benzene (<0.0001 %), and xylene (<0.0001 %).

The MSDS safety advice warned not to inhale the vapours of the product and described that inhalation might irritate the throat and respiratory system and cause coughing. To prevent exposure it was advised to use a combination filter mask (type A2/P2) when the risk of inhalation was present. Hand and eye protection was not required.

During prior voyages with this type of cargo, the crew had experienced the occurrence of hydrogen sulphide (H_2S) and was very attentive to this hazard, which they considered to be very dan-

[6] Threshold Limit Value - Short Term Exposure Limit

gerous. Therefore, the crew took precautions during discharging by wearing masks on the tank deck. However, H_2S was not mentioned in the MSDS.

3.7.2 Acute symptoms of overexposure to toxic gasses

Benzene, toluene, and xylene are aromatic hydrocarbons that are common components in gasoline and diesel oil. These substances can be absorbed in the human body through inhalation and are toxic. As described in the MSDS, exposure to benzene, toluene, and xylene can affect the respiratory system, but an acute, high exposure can also affect the nervous system and cause symptoms of intoxication, e.g. dizziness, headache, convulsions as well as deteriorating balance and muscle coordination. In case of extreme exposure, the intoxication can lead to unconsciousness and, subsequently, death. Headache and light-headedness can occur at a level of >200 PPM[7] for these aromatic hydrocarbons. The level of exposure needs to be higher and last for several hours in order for dizziness, loss of balance, and reduced muscle coordination to occur.

The PPM values on the MSDS for the three hydrocarbons that were found in the chief officer's body were: benzene (9 PPM), toluene (2 PPM), and xylene (<1 PPM).

Hydrogen sulphide develops through decomposition of organic matters and is a natural constituent of refined petroleum products; hence, it can be developed in stored process water. The primarily route of exposure is inhalation, and poisoning can occur at rather low concentrations and within a short time frame.

The acute symptoms of intoxication are connected to effects on the nervous and respiratory system. At moderate concentration (50-300 PPM) breathing difficulties, severe eye irritation, dizziness, nausea, muscle weakness, blurred vision, confusion and impaired equilibrium can occur. A high exposure level of 500-1000 PPM can lead to rapid unconsciousness and death, and these effects can occur within a few breaths.

Hydrogen sulfide has a distinct smell of rotten eggs at low concentrations, but at concentrations over 30 PPM the occurrence of H_2S cannot be detected by the smell due to olfactory fatigue. At a hydrogen sulfide level of 100 PPM the ability to smell is completely lost.

4. ANALYSIS

The fatal accident on board SCORPIUS happened as the chief officer was checking the tanks visually between cleaning and ventilation of the cargo tanks by means of taking a few steps down the tank access ladder. The injuries found on the chief officer's body as well as the damages on the heating coils on the tank bottom, indicate that he slipped on the top of the ladder and fell over the side of the handrails from a significant height.

4.1 Fall from tank access ladder

4.1.1 Aromatic hydrocarbons and hydrogen sulphide

Traces of benzene, toluene, and xylene were found in the chief officer's body, and all three substances were stated in the MSDS as being components of the cargo. It has not been possible to establish whether there were any aromatic hydrocarbons in the tank's atmosphere after the tank cleaning and, if so, at what levels. Furthermore, the traces of aromatic hydrocarbons in the chief officer's body do not indicate the levels of exposure nor when the exposure occurred. Therefore, it cannot be concluded if the chief officer was acutely exposed to any toxic substances in the tank. Benzene, toluene and xylene are common components in diesel oil, benzene, and paint, which can be absorbed at several places on board the ship and over a long term period. This

[7] Parts per million

means that the traces of these substances in the chief officer's body do not necessarily have any connection to this particular tank entry.

The MSDS was a generic document and not issued for this specific loading. It cannot be established that the composition of the discharged cargo conformed to the safety data sheet. Unless the cargo's composition deviated significantly from the generic safety data sheet, it is unlikely that the levels of toluene, benzene and xylene in the cargo were high enough to cause a level of intoxication where the narcotic properties of the aromatic hydrocarbons could compromise alertness and balance and thereby cause the chief officer to fall.

After the accident it was proved that the atmosphere in the cargo tanks contained hydrogen sulphide. The post mortal examination did not identify traces of sulphur in the chief officer's body, and it can be ruled out that exposure to H_2S was the cause of death. It is uncertain, however, whether the chief officer nervous system could have been acutely affected, leading to dizziness, staggering or loss of balance.

4.1.2 Ladder design and safety measures

Whether the chief officer slipped on the ladder accidentally or because he was under the influence of toxic substance, it proved possible to fall from a significant height of the ladder due to its design.

Though it was stated in the ship's SMS that a fall arrestor was prescribed when working 2 meters above deck, it was not common to use a fall arrestor when entering a cargo tank. Neither, was the ladder was fitted with designated anchor points or a wire to facilitate the use of fall arrestor.

The inclination of the tank access ladders on board SCORPIUS was not constant, but consisted of an inclined main part and two short vertical parts. As the inclination of the main part of the ladder was below 70 degrees and had been approved by the class without any arrangements for fall preventive equipment, it is likely that the construction of the ladder had been perceived as complying to the prescriptions in the Danish Maritime Authority's Notice B rule 7.3, meaning that a fall arrestor was not needed. If so, the vertical part at the top of the ladder was not taken in to consideration.

The top vertical part of the ladder was approx. 9 metres above the tank bottom. Since this part of the ladder was not fitted with any fall preventive measures and fall arrestors were not used at tank entry on board, the persons climbing the ladder would be unprotected from falling from the hatch coaming until the ladder started to incline.

The prevention of falls on the inclined part of the ladder was the handrail on each side of the ladder. These, however, proved not to be effective. The chief officer fell over the side of the ladder and suffered a free fall from a significant height, as the handrails were very low. Danish Maritime Authorities provisions on preventions of fall requires the hand rails to be of a solid construction and placed in a comfortable height above the treads, but does not hand out specific requirements.

The cargo tank ladder on SCORPIUS contained hazardous elements of risk in its design. The risk of falls that sprung from the design was not countered by effective fall protective measures, because the ladder was not perceived as being unsafe. Therefore, a simple slip from the top of the ladder could lead to a fatal accident.

A fall arrestor would not reduce the risk of fall from of the ladder, but might avert fatal consequences.

4.2 Tank entry

The chief officer passed the hatch coaming and stepped down the tank ladder without an entry permit. It is uncertain what his motivation for this action was, but the entry without permit could be a result of an optimized operational workflow.

The chief officer entered each of the tanks when visually checking them after tank cleaning. Most likely he was not able to get a good look from deck level and took a few steps down the ladder to get a better view. It is unknown, if the chief officer measured the gas and oxygen levels in the tank prior to entering, but it is unlikely that he stepped down in all of the tanks, if he was not convinced that they were safe to enter.

Furthermore, the chief officer might not have considered taking only a few steps down the ladder as an “entry into enclosed space” situation and therefore did not initiate the enclosed space procedure. Nothing indicates that the manner in which the chief officer checked the tanks on this day deviated from his normal conduct on board with this type of cargo.

The chief officer on SCORPIUS was responsible for the quality of the cleaning during tank wash. He would have three options if he was unsure on whether or not the tanks were clean:

1) Accept the insufficient view and move on to the ventilation of the tanks with the risk that the tanks were not clean. This could potentially mean that the tank cleaning operation would need to be repeated, which could cause a significant delay in the voyage plan.

2) Initiate the enclosed space procedure and issue entry permits for all 12 cargo tanks in order to carry out the visual check. The enclosed space procedure would require that other crewmembers needed to postpone their own tasks and/or change their resting periods in order to assist the chief officer in the tank entry. This would not be a proportionate initiative considering that the visual checking was a small standard inspection in the tank cleaning operation.

3) Utilize a grey area perception of tank entry and enter the tank without a permit by distinguishing between checking from the top of the ladder and a complete tank entry. The chief officer was experienced with both the ship, his tasks, and the cargo and it would not be unnatural for him to carry out a small standard task himself, if he assessed the atmosphere to be safe, if it would ease the workflow, and help him ensure the quality of the tank cleaning.

It is normal that operational tasks are carried out in an optimized adaption to the varying situations by balancing safety with getting the job done, e.g. due to time pressure or other goal conflicts.

It was not described in the ship’s SMS-manual how, when, and to what extent, the visual check should be carried out during the tank cleaning operation. The description of visual checking dealt with the risk of gassy vapours, solely. However, a generic description of a task cannot cover all the varying situations the crewmembers encounters, which means that there always will be situations, where the crewmembers need to adapt and act to specific circumstances.

4.3 Safety procedures

An entry permit would not have prevented the chief officer from falling. The entry permit check list required the crew to wear a harness in case evacuation from the tank was needed. This item in the check list was usually marked as “not applicable” by the crew, which means that the harness was not used. Because the harness was only to be used for evacuation, it would most likely not have been configured to the purpose of averting falls.

The safety procedure applying to tank entry was the enclosed space procedure, including the enclosed space risk assessment sheet. These comprised only the risks connecting to hazardous atmosphere. This means that the risk assessment of tank entry was reduced to concern one specific risk, and did not outline the different types of risk concerning tank entry, e.g. working in heights. The requirement of wearing fall arrestor when being 2 meters above deck tank was stated in a separate procedure about the policy for safety and work environment on board and the procedure on working in heights.

Throughout the ship's safety management system there was a tendency to focus on the safety aspects of carrying fuel or chemicals, meaning the risk of explosion, fire and intoxication. In other words, the safety management system had a predominant focus on the risks relating to the cargo and the theoretical methods to counter these. These descriptions and methods were different from the situations encountered in the operational workflow and therefore were not very helpful in crew's decision making.

5. CONCLUSIONS

The chief officer on board SCORPIUS died due to a fall from the top of a tank access ladder as he was checking the tanks visually during tank cleaning. By taking a few steps down the tank access ladder without an entry permit, he did not comply with the safety procedure on board. This, however, was not likely to have any connection to the outcome of the accident. Due to the design of the ladder, the accident could have happened on any other day even if the enclosed space procedure had been followed.

The design of the tank access ladders on SCORPIUS was a combination of an inclined and a vertical ladder, which resulted in inconsistent and inefficient fittings of fall preventive measures. The person entering the tank was completely unprotected at the top of the ladder in case of fall. Furthermore, the requirement to wear fall arrestor at tank entry was not supported by designated constructive fittings facilitating the use of these.

The safety procedures and risk assessments concerning tank cleaning and enclosed space entry focused on the risks of hazardous atmosphere and the theoretical ways to avoid them, which did not correspond with or cover the operational situations and problems of the workflow. A generic description cannot foresee and describe all tasks and their safety issues, because the operational situations on board are varying and complex. These varieties call for the crewmembers on board to adapt to the situation at hand and weigh out safety and workflow when making decisions. Therefore, there will always be a difference between work as described and work carried out.

The chief officer on SCORPIUS most likely adapted to a given situation when he decided to enter the tank without a permit. His decision was most likely based on the assessment that the tank atmosphere was safe to enter, and in this context the risk of falling was not considered a factor. Therefore fall preventive measures were not taken. The fatal accident on board SCORPIUS was not a result of an evasion of a safety procedure, but rather points to a problematic ladder design, inconsistent fall preventive measures as well as an atmosphere-focused risk assessment.

6. PREVENTIVE MEASURES TAKEN

In relation to the accident the ship owner has initiated various preventive measures to counter this type of accident. The preventive measures consists, inter alia, of safety campaigns on board, a review of the ship's safety management system, and a review of the fall protecting equipment on board and new equipment were it is found necessary.