DUTCH
SAFETY BOARD

Entrapment by hatch cranes

Extended investigation after fatal entrapment on cargo ship

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The Hague, July 2022

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Photograph cover: Vertom-Bojen, Beauforce

The Dutch Safety Board

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Dutch Safety Board

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N.B: This report is published in the English and Dutch language. If there is a difference in interpretation between the Dutch and English texts, the Dutch text will prevail.

RECOMMENDATIONS

Several initiatives to improve safety on board in general, and safe working with hatch cranes specifically, have been undertaken. The Safety Board considers such initiatives important. In addition to this the Safety Board issued the following recommendations:

To Vertom Shipmanagement b.v. and the Royal Association of Netherlands Shipowners:

1. During hatch crane operations the basic principle has to be that nobody will cross the hatch crane rails while the hatch crane is in use. If it is necessary to cross the rails, the hatch crane will not be moved.
2. Bring the risk of entrapment by hatch cranes further to the attention of the Dutch shipowners and point out the necessity of clear agreements with regard to operations being carried out in the danger zone. Make use of the experience of shipowners in defining the danger zone in relation to the hatch crane and in determining which activities should be allowed to take place in the danger zone and which should not be allowed.
3. Make clear agreements about the exact location of the danger zone in relation to the hatch crane and which activities need to be carried out in the danger zone during moving and working with the hatch crane.

To the Netherlands Maritime Technology and the Royal Association of Netherlands Shipowners:

4. Investigate together the possibilities to eliminate or reduce the risk of entrapment by hatch cranes from the design. Explicitly include:
   - The possibilities involving the design of the ship, both during the design of new ships as engineering opportunities on existing ships;
   - Methods to alert people on board of the ship of hatch crane operations in such way that it is clear when it is a direct danger for them.

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1 INTRODUCTION

1.1 Background

In the morning of 30 June 2018, in the port of St. Marc, Haiti, there was a fatal occurrence with a hatch crane on board the Dutch cargo ship Beauforce. This was the second fatal entrapment on board the Beauforce in three years. The first fatal entrapment by a moving hatch crane occurred in 2015. In the second fatal entrapment in 2018, again a crewmember was trapped between the moving hatch crane and the stacked hatches when he stepped from the hold entrance amidships onto the deck.

The risk of entrapment of a person between hatch crane and ship is actually a collision risk. Using a hatch crane on board of a ship creates the risk of people getting hit by the hatch crane. If a person cannot be pushed aside by the hatch crane because there is a hard object behind that person, such as a number of stacked hatches, we speak of an entrapment. For the purpose of readability, in this extended investigation we will use the phrase 'risk of entrapment'.

In the past, various investigations were carried out on the use of hatch cranes. For example, the Dutch Environmental and Transport Inspectorate (ILT) issued a report on the theme of hatch cranes[1] and the Finnish Accident Investigation Board published their findings in the report *Hatch crane safety*[2]. The findings from those reports were included in this present investigation.

1 ILT, Interim report theme-based campaign hatch cranes 2012 (June 2012).
2 Accident Investigation Board Finland, Hatch crane safety, (2009)

1.2 Why an investigation by the Dutch Safety Board?

The incident has been classified as a 'very serious occurrence' 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 the Netherlands, as the flag state, bears the obligation to ensure that an investigation is carried out. This obligation to carry out an investigation is also laid down in the Dutch Safety Board Act.[3]

In merchant shipping, an entrapment as described above is a frequent occurrence. In addition to the two fatal occurrences on board of the Beauforce in 2015 and 2018, this investigation will also include a previously published investigation by the Safety Board and three more fatal occurrences involving hatch cranes that were investigated by sister organisations. These six occurrences are just a few of the total number of occurrences and do not constitute a representative sample. Over the past few years, several entrapments and collisions involving a hatch crane resulting in (severe) injury or death were reported to the Safety Board. The comparison of the occurrences is aimed at obtaining an indication of any safety-related shortcomings. For this purpose, the Board also gathered information from various organisations with expertise in the field of hatch cranes.

1.3 Research questions

The Dutch Safety Board has formulated the following research questions:

1. How could the occurrence on board of the Beauforce in 2018 have happened?
2. What is the risk of becoming entrapped by a hatch crane? Which problems come to light in similar investigations and are there any common threads?
   - Was the situation on board in any way comparable with other situations where this risk occurs?
3. What measures are in place to prevent entrapment by hatch cranes and how effective are these?

3 Article 4 Dutch Safety Board Act.

1.4 Justification for the investigation

In its investigation the Board focuses in particular on the risk of becoming entrapped between hatch crane and ship, in order to identify if safety lessons can be drawn. The occurrences included in this investigation were chosen because the investigative reports contain sufficient information to enable comparison of the control measures related to entrapment. The following six occurrences were analysed:

- *Second fatal entrapment by hatch crane on board Beauforce*, 2018
- *Crew member fatality on board Toucan Arrow*, 2013
- *Entrapment by hatch crane on board Beauforce*, 2015
- *Collision involving hatch crane on board Lady Christina*, 2017
- *Crush incident on general cargo vessel Karina C with loss of 1 life*, 2019
- *Crush incident on general cargo vessel Cimbris with loss of 1 life*, 2020

The Board recognises that drawing lessons from occurrences is more effective when results are shared sooner. The large scale investigation into the MSC ZOE and the restrictions related to the Covid-pandemic caused this investigation to be severely delayed, and also caused the duration of the investigation to exceed our own standards. It was decided to carry out a multi-annual thematic investigation into the risk of entrapment in order to enhance its contribution to the safety in the sector.

2 COURSE OF EVENTS AND ANALYSIS BEAUFORCE, 2018

This section first describes the course of events regarding the occurrence on board of the Beauforce on 30 June, 2018[4] . This will be followed by an analysis of the occurrence. The occurrence will be investigated from two perspectives. Firstly, the safe operation of the hatch crane, and secondly the safe working conditions within the working range of the hatch crane. In conclusion, the design of the hold entrance amidships will be addressed.

2.1 Course of events Beauforce, 2018

In the morning of 30 June 2018, in the port of St. Marc, Haiti, there was a fatal occurrence on board the Beauforce. A crew member of the Dutch merchant vessel got trapped between the moving hatch crane and the stacked hatches when he stepped from the hold entrance amidships onto the deck. At that time, the hatch crane was used to close the hatches of hold number 1.

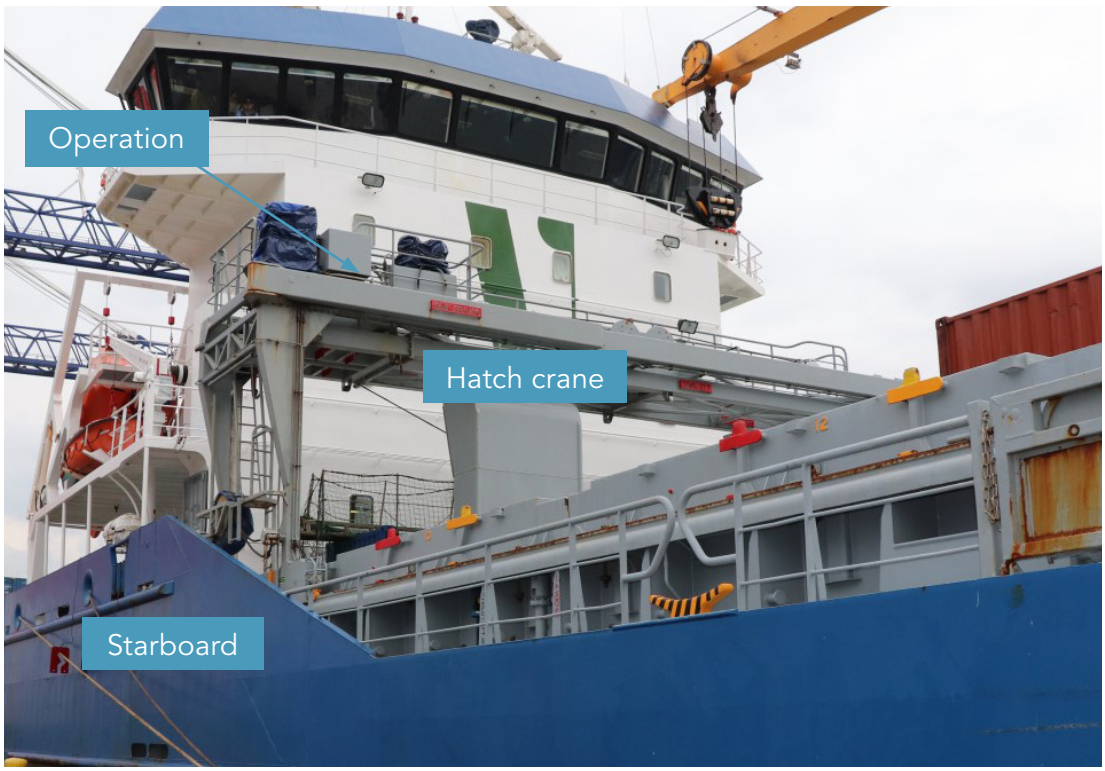


Figure 1: Hatch crane in home position, seen from the shore (starboard).

4 A detailed description of the course of events is included in Appendix B.

Hatch crane

A hatch crane (also known as hatch cover gantry crane) is a moveable crane that mainly consists of two vertical supports and a horizontal transverse beam. The operator usually stands on top of the hatch crane and moves along with the crane during operation. Figure 2 shows the operator position and the direction of travel as it was at the moment of the occurrence on board of the Beauforce in 2015.

The hatch crane is used, among other things, for moving the pontoon hatches and deck hatches of the ship. Deck hatches are used for closing off the cargo hold(s), and pontoon hatches are used for horizontally or vertically adapting the layout of the hold. Hatch crane operations are usually done in preparation of, during or after loading and/or unloading.

A hatch crane moves the hatches along the longitudinal axis of the ship. It rides on rails running on both sides of the ship, fitted to the hatchway coamings. A hatch crane can only be used when the ship is almost horizontal without trimming or does not list which could cause the crane to shrank and rendering it unsafe for use. For this purpose, the manufacturer has indicated limit values.

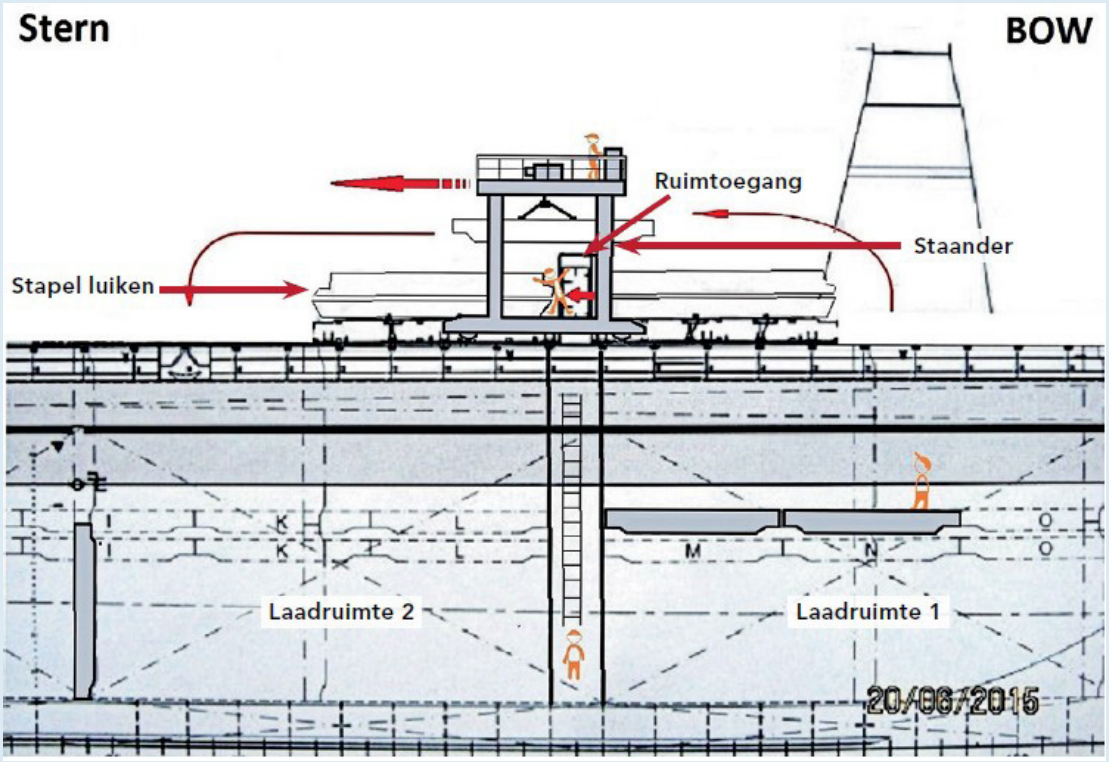


Figure 2: Illustration of the hatch crane. (Source: Focus Shipmanagement)

When the unloading of the cargo from hold no. 1 was almost completed, three crew members received the order to close the hatches of the hold. The crew member charged with operating the hatch crane walked to the hatch crane en clambered up to the location of the controls. The other two crew members would assist the operator from the gangway. After switching on the hatch crane, the operator asked via transceiver if the operating range of the crane was free from obstacles. This was confirmed by the other two crew members, one of which the later victim. Subsequently, the operator moved the crane in the direction of the bow and during this movement the victim got entrapped amidships. Immediately after the accident the operator was made aware of the mishap by local stevedores and a fisherman. The victim was on the port side, completely hidden from view to the operator on the starboard side.

Figure 3: Hatch crane near the hold entrance on port side.

Figure 4: Hold entrance on port side, showing the watertight door and the stacked hatches.

The investigation has shown that the victim after answering the question asked by the crane operator was still on his way from the hold entrance amidships to the gangway on port side. At the moment he stepped from the hold entrance onto the port side gangway, he got entrapped by the moving hatch crane. Trace evidence has shown that he became entrapped between the portal (vertical support) of the hatch crane and the watertight door or the stacked hatches. The victim was 'taken along' by the moving crane and became entrapped. Subsequently, the victim fell forward onto the gangway, located at a lower level.

Similarities and differences compared with the first entrapment on the Beauforce, 2015

The occurrence on board of the Beauforce in 2018 was the second fatal entrapment in three years. In both cases, the victim was outside the visual field of the operator. Just like the first case, in 2018 the victim got entrapped between the moving hatch crane and fixed elements of the ship after emerging from a hold entrance amidships. In both cases, none of the crew saw what happened, but in 2018 local stevedores and a fisherman saw the occurrence taking place.

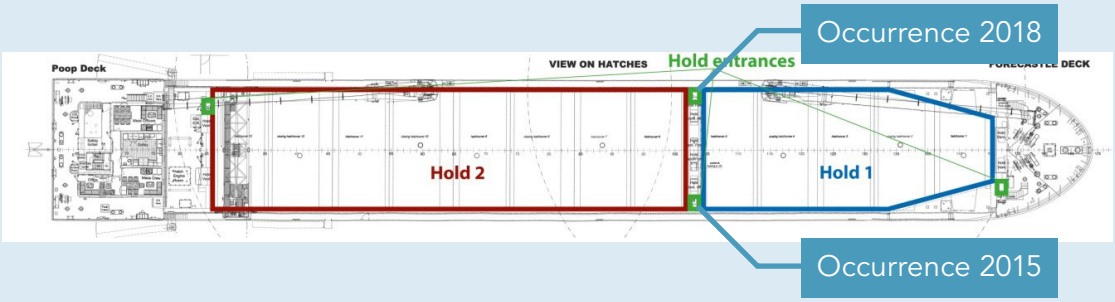


Figure 5: Ship's layout showing the location of both occurrences.

The investigation into the occurrence on board the Beauforce in 2015 learned that when designing this type of ship it was decided to create an additional entrance to the cargo hold amidships. Thus the Beauforce has two cargo holds, separated from each other by a central bulkhead.

The fatal occurrences on the Beauforce happened in almost identical locations, namely the hold entrance amidships, the only difference being that in 2015 the occurrence was on the starboard side and in 2018 on the port side. On the Beauforce the hold entrance is amidships with a small portal at the top and a threshold (see figure 6). The threshold is 60 cm high and is intended to keep a safe freeboard. Within the portal there is a small landing at the top of a ladder giving access to a shaft of some 8 metres deep. This shaft provides access to the hold.

Figure 6: Access to hold number 1 on port side; location of occurrence 2018.

When someone steps outside from the hold entrance amidships across the threshold, there is a distance of about one metre before reaching the steps leading to the gangway at the lower level. This requires stepping across the rails of the hatch crane. The entrapments of 2015 and 2018 occurred at the moment the victims stepped across the rails.

Regarding the Beauforce occurrence of 2015, the Board concluded that the occurrence was an unfortunate combination of circumstances. However, based on the fact that a similar occurrence took place in 2018, the suspicion rose that this is a serious and recurring danger on board ships fitted with a hatch crane. Therefore it was decided to carry out an extended investigation involving six different occurrences.

2.2 Limitations in the safe operation of hatch cranes

When operating a hatch crane, the crane will travel in longitudinal direction of the ship on the rails located between the cargo holds and the gangway. If during the movement of the crane people can be present in the working area of the crane, there will be the risk of people getting hit by the crane and becoming entrapped between the hatch crane and parts of the ship. On board the Beauforce various measures are in place for safe operation of the moving hatch crane. These are control measures set out in the procedure that was present on the hatch crane and at the disposal of the operator (see appendix C). The following control measures in the procedure are relevant to the analysis of the occurrence:

- *Check the area and the rails yourself for any obstacles such as people or material;*
- *Have at least two people assist you when opening and closing the hatches;*
- *Make sure to retain visual contact with the assisting people and stop moving the crane when visual contact is lost.*

The following two findings indicate limitations for the operator regarding the safe operation of a moving hatch crane.

Restricted view

The investigation into the first fatal entrapment on board the Beauforce in 2015 showed that the view of the operator of the hatch crane was severely restricted. The position of the operator and the restricted view were the same in 2018 and therefore the operator could not see whether or not the victim had accessed the gangway. Considering the accident of 2018, the situation described above rendered the first control measure of the procedure infeasible. From his position the operator of the hatch crane could not see if there was anyone present in the port side gangway. People emerging from the hold entrance amidships were not visible to him. This is because the crane controls are on the starboard side. Furthermore, the construction of the hatch crane itself obstructs the view of the area immediately below the hatch crane.

This makes that the operator himself cannot see if the path of the hatch crane is clear. For this he largely depends on the input of others. The restricted view for the operator of a hatch crane is also mentioned in the ILT interim report on hatch crane[5].

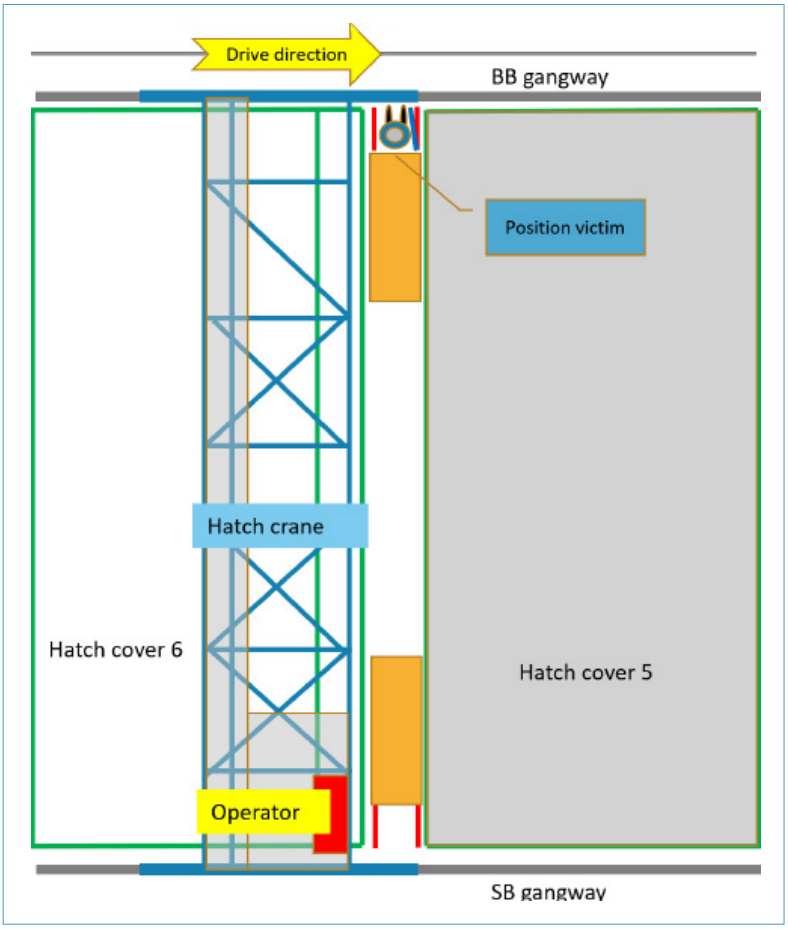


Figure 7: Top view with position of victim in 2018.

Partial conclusion

The operator's field of view is severely restricted and does not allow him to have a proper overview of the crane path. This is the reason why he needs assistance to be able to operate the hatch crane safely.

Communication

The second finding concerns the limitations in communication. One of the control measures is that in order to help mitigating the restricted view, the operator must be assisted by two people (one in each gangway). At the time of the occurrence in 2018 a procedure was followed whereby the operator would check over the transceiver if he could start moving the crane. The investigation showed that he actually had followed this procedure. The operator claimed to have received a message for 'all clear' and that he therefore assumed that he could move the crane without risk.

5 ILT, Interim report theme-based campaign hatch cranes 2012 (June 2012).

Despite this, the victim still got entrapped. The investigation did not make clear what caused the misunderstanding in the communication, but it was concluded that there was a difference of interpretation. The operator understood from the communication that the crane path was clear, which did not appear to be the case.
The 2018 accident occurred when the operator moved the crane without being able to see both assisting crew members, and the investigation showed that it was not clear where the victim was at that moment. This caused also the third component of the procedure to fail as the operator started moving the hatch crane without having visual contact with the assisting crew members. Communication is an additional and important control measure since the view of the operator is restricted. The effectiveness of the measure depends on the working conditions. Communication between the operator and the two assisting crew members in both gangways was meant to prevent the crane from moving at the moment that someone might be in its path. However, communication is a less direct way of obtaining situational information than visual observation and has a number of limitations in getting the information across, including:

- The sender can say one thing and mean another;
- The message can be heard incorrectly;
- The message can be misunderstood.

These limitations are additional to the restricted view of the operator. Apart from the limitations in the communication as indicated above, factors such as ambient noises and limitations or malfunctions of the communication tool affect the reliability of the control measure.

Partial conclusion

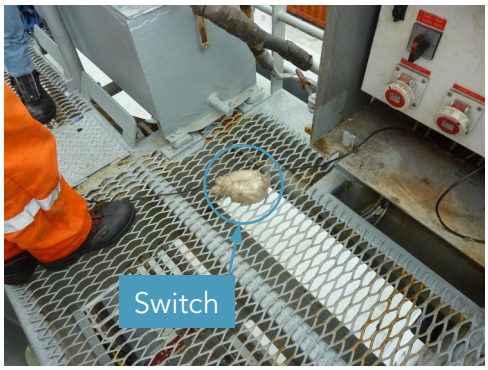
Communication with others is essential for determining if the hatch crane can be operated in a safe manner. This introduces the risk of miscommunication.

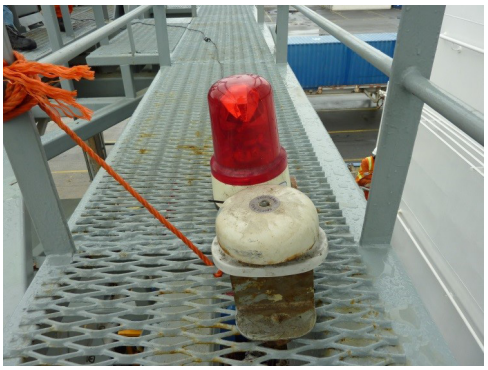
The available information on the occurrence has shown that the operator asked if he could start moving the crane and that the victim said that the crane path was 'clear'. There must have been some form of miscommunication and it was unclear where the victim was when the operator asked him for clearance.

2.3 Limitations in safe working in path of hatch crane

On the Beauforce, measures were taken to reduce the risk of entrapment of people working in or near the path of the hatch crane. For example, the hatch crane was fitted with acoustic and optic alarms as standard. The alarms activated automatically as soon as the hydraulic system of the hatch crane reached working pressure. The system is activated by a pressure switch at a pressure between 25 and 250 bar. Upon reaching working pressure the bell and strobe light are activated. In this setup the alarm is permanently operative as soon as the drive is switched on, even without the crane actually moving. This reduces the attention value of the alarm.

At the time of the occurrence in 2018 the original alarm bell was defective. Since there were no spare parts on board, the bell could not be repaired immediately. For this reason an alternative alarm system was in operation. This alternative alarm system required manual operation. The operating switch of the alternative alarm system was located next to the controls of the hatch crane. This system also caused the alarm to sound louder near the operator, causing other sounds to be drowned out and less audible for the operator. In addition, the bell was further away from the locations where the risk of collision with the hatch crane was present, such as the gangway and the hold entrance amidships. In some instances the alarm was not switched on. The statements made by the witnesses as to whether or not the alarm was sounding at the moment of the occurrence are ambiguous.





Alternative alarm system with on the left (figure 8) the switch and on the right (figure 9) the alarm bell and the strobe light.

In addition to the acoustic and visual alarms, the hatch crane was fitted with emergency stop buttons that could only be reached from the gangways. The investigation showed that the victim could not reach the emergency stop button. The emergency stop button was out of the victim's reach. Later it was found that the emergency stop button was defective without this being known prior to the occurrence.

Partial conclusion

There were limitations in the control measures that were put in place in order for people to work in safety in the path of the hatch crane. The alarm required manual operation and was located high on the hatch crane. Therefore, it is not sure whether the alarm was sounding and if it was audible in the location of the victim. The hatch crane was also fitted with emergency stop buttons. However, the emergency stop button was out of reach of the victim and later appeared to be defective.

2.4 The design of the hold entrance amidships is a risk increasing factor

The Beauforce belongs to the first generation of the 'Damen Combi Freighter 8200'. On these ships, the entry of the hold entrance amidships is facing the gangway. This series of ships has two hold entrances amidships. The second generation however, is of a different design: the ladder has been rotated through 180 degrees and there is no portal on the deck. Instead of the portal, this generation of ships has a 60 cm high hatch.

When someone wants to use the hold entrance amidships, the rail of the hatch crane needs to be crossed when accessing or leaving the gangway. This means that everyone using this entrance will be in the path of the hatch crane. This design therefore increases the risk of entrapment. The door of the portal is facing the crane track. There is a small distance between the portal and the crane track. Figure 10 shows the situation on the port side of the Beauforce.

The hold entrance amidships creates a walking route that crosses the path of the hatch crane. The door opening in the direction of the crane path and the short distance between the door and the gantry increase the risk.

Figure 10: This photograph shows that anyone stepping from the hold entrance amidships is very near to the path of the hatch crane.

Partial conclusion

The route from the centre bulkhead to the gangway via the hold entry amidships is risk increasing. This created a route that crosses the path of the hatch crane. The design of the portal, the doorway facing the crane's path and the short distance between the two, increases the risk of becoming entrapped.

3 COURSE OF EVENTS AND BACKGROUND INFORMATION OTHER OCCURRENCES

This section summarises the course of events and analysis of the five occurrences that were included in the report on the occurrence on the Beauforce in 2018. Firstly, an overview of the details concerning the ships and the occurrences as well as general information on hatch cranes is presented. Next, the occurrences will be described in detail.

3.1 Details of ships and occurrences

This paragraph contains a schematic of the details of the ships and occurrences and provides further information on the hatch cranes.

Ship name	Toucan Arrow	Beauforce	Lady Christina	Karina C	Cimbris
Date	07-10-2013	09-06-2015	15-11-2017	24-05-2019	14-07-2020
Flag State	Bahama's	The Netherlands	The Netherlands	Great Britain	Gibraltar
Location	Portland, Australia	Colón, Panama	Rauma, Finland	Seville, Spain	Antwerp, Belgium
Type of ship	Geared general cargo	Multipurpose general cargo vessel	General Cargo with Container Capacity	General cargo vessel	General cargo vessel
Vessel length	199,7 m	118,14 m	108 m	106,07 m	98,9 m
Hatch crane operations preceding the occurrence	Preparing hatch crane for stevedores and collection of material	Changing the ship's configuration for new cargo	Hosing down the deck after consignment of china clay in preparation of a consignment of paper	Closing the hold in preparation of departure from port	Displacement of stacked hatches during unloading of cargo
Outcome of incident	Victim deceased	Victim deceased	Victim deceased	Victim deceased	Victim deceased
Operational tasks of victim	Unknown	Cleaning the hold	Helping with hose on deck	Sweeping up concrete dust from hatchway coaming	Coordinating the unloading of cargo
Probable actions of the victim	Repairing strobe light	Left the hold for unknown reasons	Installing end cap on drainage pipe	Sweeping up concrete dust from hatchway coaming	Coordinating the unloading of cargo

3.2 Toucan Arrow, 2013[6]

On 7 October 2013, on board of the cargo vessel Toucan Arrow in the port of Portland, Australia, a crew member became entrapped between the hatch crane and a hatch cover. A number of crew members were busy preparing the hatch crane for loading and unloading operations by stevedores which involved occasional movements of the hatch crane. After the hatch crane had been prepared for cargo operations, the crane operator was asked to move the crane over some distance in order to pick up some material. During these operations a crew member saw the victim lying injured on the deck and raised the alarm.

Figure 11: Toucan Arrow showing both hatch cranes. (Source: ATSB)

6 Australian Transport Safety Bureau, Crew member fatality on board Toucan Arrow, 2013. To be found on: https://www.atsb.gov.au/publications/investigation_reports/2013/mair/303-mo-2013-010/

Nobody saw what happened, and therefore investigation by the Australian Transport Safety Bureau (ATSB) was not conclusive as to the actions of the crew member at the time of the occurrence. Tools and a new warning light were found close to the accident location. Partly on the basis of this finding, the ATSB concluded that the victim probably had the intention of replacing the defective warning light of the hatch crane and that he had climbed up two hatches in order to do so. On the basis of forensic evidence it is assumed that he became entrapped between the stacked hatches and the moving hatch crane.

The ATSB states that prior to the assumed actions of the victim there had not been any communication in relation to his intention of repairing the warning light. The acoustic alarm was serviceable but could not be heard from the victim's location. As the warning light was defective, he probably did not notice the hatch crane moving his way. Figure 12 shows the assumed location of the victim during the entrapment.

Figure 12: Reconstruction of the occurrence; the victim was probably standing on a ladder of the stacked hatches. (Source: ATSB)

3.3 Beauforce, 2015[7]

Tuesday 9 June 2015, a crew member of the Dutch cargo vessel Beauforce became entrapped by the hatch crane. At that moment the hatch crane was being used to move pontoons in order to prepare the cargo holds for taking on new cargo. The ship was at anchor awaiting passing through the Panama Canal.

Figure 13: Beauforce. (Source: Focus Shipmanagement BV)

The captain had elaborated the new configuration of the ship in preparation of the new cargo. Based on this configuration, the crew members involved received the assignment for preparing the cargo holds. The holds needed to be cleaned, the tweendecks, formed by pontoons, needed to be removed and a number of them had to be installed as bulkhead.

Later in the day, the hatch crane moved from cargo hold 1 to cargo hold 2. The later victim was working with a colleague in hold 2 and decided to leave the workplace. He only shared this with his colleague in the hold. Then he climbed the ladder of the hold entrance to the deck portal on starboard side. Upon arrival in the portal he stepped across the threshold of the open door. His colleague waited at the bottom of the ladder but did not receive the usual signal from his colleague that he had cleared the ladder. Therefore he decided to climb the ladder anyway and when leaving the deck portal he found his colleague severely entrapped between the hatch crane and a stack of hatches. The injuries sustained by the victim were of such a nature that help was to no avail. The investigation failed to find why the victim left his workplace.

7 Dutch Safety Board, Entrapment hatch crane, 2016. To be found on: https://www.onderzoeksraad.nl/nl/page/3990/beknelling-luikenwagen-9-juni-2015

Nobody on board saw the accident happen. The crane operator did not have a view of the area directly below him at the location where the victim emerged from the hold entrance. One crew member in the port side gangway walked along with the hatch crane but had no view of the accident location in the gangway on starboard side. Partly due to the vibrations in the ship it must have been clearly noticeable to the victim that the hatch crane was moving. The victim probably tripped when he stepped from the hold entrance amidships and ended up in the path of the crane.

3.4 Lady Christina, 2017[8]

The Dutch cargo vessel Lady Christina was moored in the port of Rauma (Finland), where it had unloaded a cargo of China clay. After the unloading, the ship was cleaned by the crew. During the cleaning operations, the crane operator moved the hatch crane slowly over the hatch coaming, which was hosed clean from the crane (see figure 14). During the operations a deckhand was found dead in the port gangway. Nobody on board saw the accident happen.

Figure 14: Crane on board the Lady Christina. (Source: Dutch Safety Board)

8 Dutch Safety Board, Collision with crane, Fatal accident on board Lady Christina, 2018. To be found on: https://www.onderzoeksraad.nl/nl/page/4879/aanrijding-door-kraan-aan-boord-lady-christina-15-november-2017

The coaming was cleaned with the help of the ship's large crane. The crane on board the Lady Christina is not a true hatch crane. Operating this crane is however comparable to using a hatch crane and therefore relevant to this investigation. The cleaning work was carried out by several crew members, including the later victim. The victim was given the task of guiding the deck cleaning hose in the starboard gangway. He received instructions over his transceiver. The hose was fairly rigid and could easily get caught on something. If this happened, the victim would be instructed via his transceiver to free it.

The hatchway coaming of the Lady Christina is fitted with a water channel and drain pipes. These drain pipes are fitted with an end cap with integrated non-return valve. The investigation showed that it can be assumed that the victim was trying to screw the end cap on the drain pipe on the port side, and was struck by the moving crane while doing so. The forensic investigation confirmed that the victim must have climbed onto pipe sections situated below the crane rails, and was then struck by the moving hatch crane. The victim died of his injuries.

Nobody knew that he was planning to do this while the crane was moving. The victim never indicated that he would be situated in the path of the crane. Because of the size of the hatch crane, the operator had no view of the lower gangway. Apart from the crane operator and the crew member holding the cleaning hose, there was another crew member acting as cable watch while the crane was moving. His view of the gangway was limited and he could not see the section immediately below the crane, were the victim was. The evidence suggests that while the crane was moving, an acoustic signal was clearly audible. The hatch crane was also fitted with an emergency stop button. The emergency stop button is located at the position of the cable watch.

3.5 Karina C, 2019[9]

On 24 May 2019, a crew member on board of the cargo vessel Karina C in the port of Seville, Spain, got entrapped between a stack of hatches and the moving hatch crane. Earlier that day, the ship's agent had told the captain at 09.00 hours that the time of departure had been brought forward form 14.00 hours to 11.30 hours on that same day. At that time, the hatch crane was used to close the hatches.

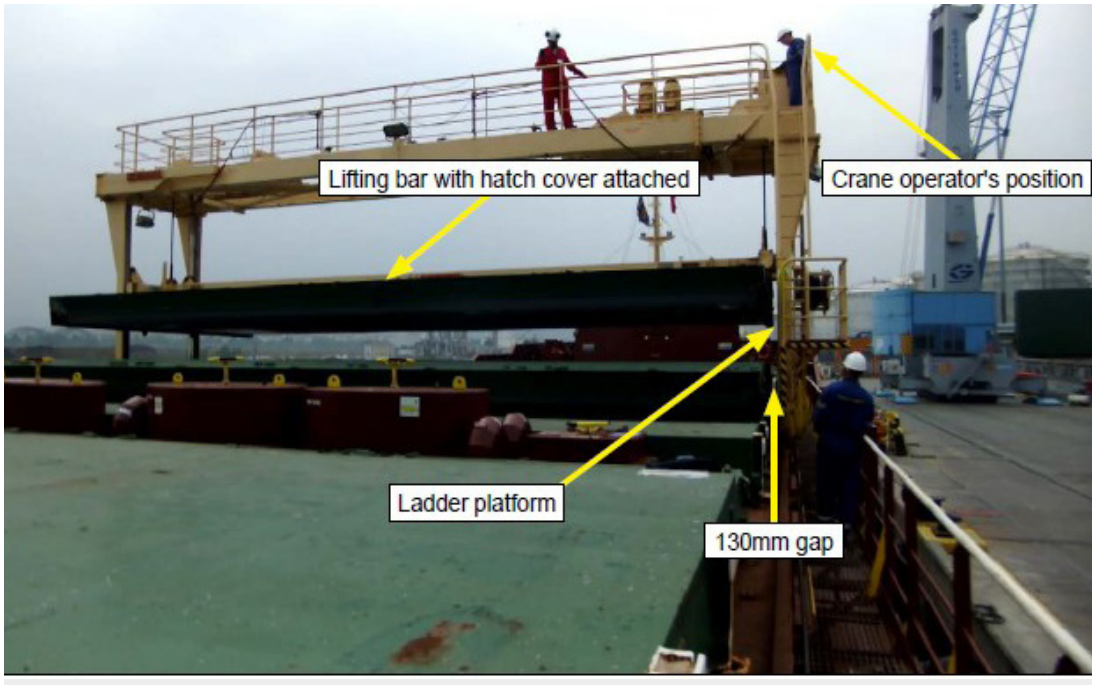


Figure 15: Hatch crane viewed from the stern of the ship. (Source: MAIB)

After it became clear that the vessel had to depart earlier, the later victim went on deck to sweep up cement dust. This took place simultaneously with hatch crane operations. Shortly before the occurrence, the operator stopped the hatch crane near a stack of hatches at the same time the later victim was also there. The later victim then climbed on the hatchway coaming in order to step between the hatch crane and the stack of hatches. The crane operator did not notice this. At the same time the victim moved between the hatch crane and the stack of hatches, the operator started moving the hatch crane which caused the victim to become entrapped (see figure 16 and 17 for the MAIB reconstruction). The victim died of his injuries.

9 Marine Accident Investigation Branch, Crush incident on general cargo vessel Karina C with loss of 1 life, 2020. To be found on: https://www.gov.uk/maib-reports/crush-incident-on-general-cargo-vessel-karina-c-with-loss-of-1-life

Figure 16: Reconstruction of the victim climbing between the stack of hatches and the stationary hatch crane. (Source: MAIB)

Figure 17: Reconstruction showing the space between the stacked hatches and the hatch crane. (Source: MAIB)

3.6 Cimbris, 2020[10]

On 14 July 2020, a local stevedore became entrapped between the moving hatch crane and a hatch on board of the cargo vessel Cimbris. At that time, the hatch crane was being used to move the hatches during unloading of the cargo. The victim coordinated the operations of the other stevedores on board the ship.

The later victim gave instructions to the operator of the quay crane using a transceiver. In order to look into the hold, he climbed a ladder and leaned over the edge of the 2 metre high hatchway coaming. When unloading of the rear part of the hold was almost completed, the hatch crane was used to move a stack of hatches. The investigation of the Marine *Accident Investigation Branch* (MAIB) describes that the hatch crane suddenly stopped. The operator did not see that someone had become entrapped, but someone else saw the victim being entrapped.

10 Marine Accident Investigation Branch, Crush incident on general cargo vessel Karina C with loss of 1 life, 2021. To be found on: https://www.gov.uk/maib-reports/crush-incident-on-general-cargo-vessel-cimbris-with-loss-of-1-life

Figure 18: Hatch crane on board the Cimbris (photograph taken from starboard looking forward). (Source: MAIB)

It did not become clear when and why the victim moved in the path of the crane. He probably wanted to lean over the hatchway coaming to communicate with or to supervise the stevedores in the hold. He could have used the transceiver provided, but it was common practice to climb onto the hatchway coaming. The MAIB analysis showed that it is likely that the victim was aware of the moving hatch crane but miscalculated the speed with which it was approaching him. He probably thought to have sufficient time to climb up and down before the hatch crane would reach him. The victim died of his injuries.

4 COMPARISON OF OCCURRENCES

In this section, the six occurrences will be compared with each other. First the risk of entrapment is further described, then the four levels of control measures will be discussed. Using the six occurrences, the feasibility and the limitations of the various control measures will be looked into.

4.1 The risk of becoming entrapped between the hatch crane and parts of the ship

Central to this research is the risk of becoming entrapped or crushed between the hatch crane and the ship. The potential consequences of this risk can be very serious. In all cases described earlier, the consequence of the risk was that the victim died as a result from colliding with or becoming entrapped by the hatch crane. This relates to the relatively large mass and rigidity of its construction. A human is vulnerable and a collision with a hatch crane can be instantly fatal. Even when using personal protective equipment, a human does not stand a chance against a moving hatch crane. The path of a hatch crane is therefore a permanent danger zone when the hatch crane is in use. In view of the fact that in four of the six occurrences the victim entered the path of the hatch crane after coming from the gangway (in case of the Beauforce both victims were emerging from the hold entrance), the gangway is also seen as a danger zone.

The risk of entrapment by a hatch crane is a well-known risk in the industry. Various investigations have illustrated this. The manual 'Dat is Juist!' (That's Right!) details safe working with hatch cranes and mentions that 'many fatal occurrences are known to have happened involving crew members becoming entrapped'.

Dat is Juist! (That's Right!)

That's Right! is a publication from the *Stichting Scheepvaart shipping foundation,* with contributions from a committee (the Working Conditions & Safety Committee (CAV) of representatives of employers' and employees' organisations from merchant shipping, wet maritime engineering and sea fishing, maritime education and the Netherlands Shipmasters Association (*Nederlandse Vereniging van Kapiteins ter Koopvaardij*) and is part of the Maritime Platform Association for Employment, Income and Health (*Vereniging Platform Maritiem voor Werk, Inkomen en Zorg*).

The purpose of this book is to describe what is generally accepted as normal, safe or healthy professional practice.

First and foremost, the book is intended for anyone on board a ship and can be used as study material for maritime training or for updating an ISM system. The book also contains all existing Health and Safety Catalogue pages, in their entirety.

In producing the updates, results of investigations by the Dutch Safety Board have been included, as far as possible. That's Right! can be ordered free of charge or downloaded via the CAV page on the website of the Stichting Scheepvaart foundation.[11]

Section 14.5.4 of That's Right! on hatch cranes
Many occurrences, including fatal ones, are known in which seafarers became entrapped and were not able to stop the moving crane or warn others because of ambient noise. There have also been various and also fatal occurrences by using the hatch crane as crane by attaching work cages, or for the purpose of installing or removing bulkheads or tweendeck components. Section 14.7 provides an overview of these occurrences.

Since the risk of entrapment is a known risk, control measures were introduced. To be able to determine the effectiveness of control measures, the occupational health strategy may be used. The occupational health strategy distinguishes four levels. The idea behind the occupational health strategy is that control measures are used in a certain sequence, first looking at the source of the problem. Tackling the source means that actions are taken to find solutions, in order to protect people from harm as much as possible. If tackling the source is possible only to a limited extent, appropriate control measures need to be taken. This means that first of all the safest control measure needs to be considered (for instance a fully enclosed work station at height that prevents people from falling). If there are compelling reasons not to apply the safest control measure, the next safest control measure is to be considered. This is referred to as the *principle of reasonableness.* So it is important that the conceivable measures are considered in the correct sequence. Concerning the risk of entrapment by a hatch crane, the four following levels of control measures can be identified:

- *Physical separation*
  It is physically impossible for persons to be in the path of the hatch crane
- *No other operations in the hatch crane danger zone*
  No operations in the path of the hatch crane when it is in use
- *Safe operation of hatch crane*
  How the operator is equipped to prevent entrapment
- *Working safely in the hatch crane danger zone*
  How a potential victim working in the path of the hatch crane is equipped to prevent entrapment

11 Stichting Scheepvaart, 'Commissie Arbo & Veiligheid (CAV)', https://www.scheepvaartnet.nl/?pagina=458&menu=269 [last accessed on 01-03-2022].

The starting point of the occupational health strategy is that measures need to be in place as close to the source as possible. The first option would be to use ships without hatch crane, eliminating the risk of persons becoming entrapped between a hatch crane and the ship. This option falls outside the scope of the investigation, as the current practice is that there are ships with hatch cranes in use and that any alternative for a hatch crane might impose other risks. The next level constitutes 'collective measures', meaning the physical separation of persons and the moving hatch crane.

4.2 Control measures overview

An overview of the control measures was compiled using the available information on the six occurrences. On the basis of the four levels, for each of the accidents it is indicated if the control measures were in place. 'Safe operation of hatch crane' and 'Working safely in working area of hatch crane' consist of different control measures.

Control measures	Toucan Arrow, 2013	Beauforce, 2015	Lady Christina, 2017	Beauforce, 2018	Karina C, 2019	Cimbris, 2020
Physical separation	No, victim entrapped when climbing hatchway coaming	No, victim entrapped when emerging from hold entrance amidships	No, victim entrapped when climbing in gangway	No, victim entrapped when emerging from hold entrance amidships	No, victim entrapped when climbing hatchway coaming	No, victim entrapped when climbing hatchway coaming
No other operations in the hatch crane danger zone	No, victim was replacing defective alarm in danger zone	No, victim used route through danger zone	No, victim fitted end cap on drain pipe in danger zone	No, victim used route through danger zone	No, victim was sweeping up concrete dust in danger zone	No, victim coordinated other operations in danger zone
Safe operation of hatch crane						
Operator view	Unlikely that the operator had seen the victim	Operator could not see the victim	Operator could not see the victim	Operator could not see the victim	Operator could not see the victim	Operator could not see the victim
Communication	There was no communication between operator and victim	There was no communication between operator and victim	There was no communication between operator and victim	There was miscommunication between operator and victim	There was no communication between operator and victim	There was no communication between operator and victim
Assistance from people in gangway	Nobody saw the accident happen	Nobody saw the accident happen	Nobody saw the accident happen	None of the crew saw the accident happen	Nobody saw the accident happen	Nobody saw the accident happen

Control measures	Toucan Arrow, 2013	Beauforce, 2015	Lady Christina, 2017	Beauforce, 2018	Karina C, 2019	Cimbris, 2020
Working safely in the hatch crane danger zone						
Alarms	Alarm was inaudible, strobe light defective	Alarm was audible, it was clearly noticeable that the hatch crane was moving	Alarm was clearly audible	Alarm was marginally audible, improvised alarm system	Alarm was clearly audible	Alarm was audible, it was clearly noticeable that the hatch crane was moving
Emergency stop button	Not reachable	Not reachable	Not reachable	Not reachable	Not reachable	Not reachable

4.3 Physical separation

From the fact that all six accidents occurred it can be deducted that there was no physical separation in place. If that had been the case, the victims would not have been hit by a moving hatch crane. Regarding the six occurrences a distinction can be made as to the way in which someone may end up in the path of the hatch crane.

In four out of six occurrences the victim climbed up and inadvertently found themselves in the danger zone. However, the various occurrences show a difference as to the ease with which a person can enter the path of the hatch crane or the reason for doing so. The situation on board of the Beauforce is different from the situation on board the other ships. Paragraph 3.3 already mentioned that the hold entrance amidships of the Beauforce creates a walking route that crosses the path of the hatch crane. The design of the crane on board the Lady Christina makes it more difficult for a person to enter the crane's path. Here, the victim had to climb up from the gangway and did this intentionally to place an end cap on a drain pipe.

Partial conclusion

In none of these occurrences physical separation was established. Because of the hold entrance amidships, the situation on the Beauforce is different.

4.4 No other operations in the hatch crane working area

If physical separation of persons and a moving hatch crane is not possible or only partially effective, a separation of time may be put in place. This means that no operations in or near the path of the hatch crane are allowed when the crane is moving. The six occurrences show that this working method is not common practice. In five of the six occurrences the victim was busy with other operations at the moment the (hatch) crane was moving. Also, these operations had not been planned or discussed earlier with the crew involved in hatch crane operations. The 2018 victim on the Beauforce was expected to be in the working area of the hatch crane, but the operator assumed the victim was in the gangway. All occurrences have in common that the definitive circumstances are unknown and that therefore it is unknown why the victim was in the path of the hatch crane. It is worth noting that the actions of the victim in or near the crane path prior to the occurrence are unclear. Therefore, it would seem that the path of the crane is a danger zone.

Hatch crane operations are usually done when the ship is at anchor or berthed, and mostly before or during loading and/or unloading. These are moments when various other operations are carried out, making it conceivable that operations need to be combined. It is also conceivable that at these moments people will be using the gangway while the hatch crane is moving nearby. Looking at the six occurrences, it appears to be common practice that other operations are carried out in the working area of the hatch crane while it is in operation.

Partial conclusion

In five out of six occurrences other operations were being carried out in the path of the hatch crane that were not related to hatch crane operations.

The hatch crane is mostly used when loading and unloading, which is a moment when it is conceivable that various operations need to be carried out simultaneously in the same location. This underlines the importance of coordinating operations.

4.5 Safe operation of hatch crane

If other operations are being carried out in the working area of the hatch crane, the risk management will be partly dependent on the safe operation of the hatch crane. In practice, this means that a crane operator receives instructions aimed at increasing safety when operating the crane. However, these instructions are limited in effectiveness because of the conditions under which the operator carries out his task.

Restricted operator view
In line with earlier research by the ILT, the comparison of the six occurrences has shown that in all cases the view of the hatch crane operator had been restricted. The crane operator had no view or had a restricted view of the location where the accidents occurred.

Based on the findings and the ILT interim report on the use of hatch cranes, it is clear that because of their restricted view operators cannot operate the hatch crane safely as these restrictions render it impossible for the operator to use his own judgement. This is important, as this makes the operator dependent on others for risk control. Therefore, ILT mentioned in its interim report that there always needs to be a second person to assist the crane operator and that the crane operator needs to confirm with this person that the crane path is clear of obstacles. This means that there always needs to be communication between the operator and the second person.

Partial conclusion

In none of the six occurrences, the crane operator saw the occurrence coming or happening. This suggests that because of his restricted view the operator could not judge whether or not he could safely move the hatch crane.

Restrictions in communication
In paragraph 2.1 it was identified that communication can fail in different ways. Communication is an indirect way of obtaining situational information and therefore is prone to various limitations in getting the information across. Apart from miscommunication it is also possible that there is no communication at all.

In only one of the six occurrences there was miscommunication. In the other five there had been no communication at all. Also, there was a person carrying out operations that were not directly related to the use of the hatch crane. In these occurrences, the crane operators were not aware of the location of the victim in the path of the crane. This means that the victim himself should have communicated his intention to enter the danger zone. For effective risk management this is an undesirable situation, as in this scenario an error by a potential victim may have a fatal outcome.

Partial conclusion

In five of the six occurrences there had been no communication concerning the victim entering the crane's danger zone. Because the victim was performing other operations, the responsibility for communication factually rested with the victim.

Dependency on support of other people
Apart from a potential victim communicating with the operator, it is also possible to have other people assist the operator. These people can help with operations involving the hatch crane and can also provide the operator with information on the crane path.

In all six occurrences there was nobody else but the victim in the gangway where the accident occurred. There was nobody there to assist the operator, and if there were they had no view of the accident location or the person assisting became victim himself. Because of the restricted view of the operator he is dependent on assistance, and the six occurrences show that this can go seriously wrong. Assistance may be lacking altogether. If assistance is provided, this does not guarantee that a potential victim will be timely alerted or that there will a timely response to a dangerous situation.

This a weak control measure, as the different steps need to be successfully and timely carried out for the control measure to be effective. There must be someone present to monitor and intervene. This person should have a view of the imminent danger as well as be able to respond and act in time. In all six occurrences this did not appear to have been the case.

Partial conclusion

Communication with people assisting the operator is a way of avoiding the lack of communication by third parties. However, it appears that in all six occurrences there was nobody monitoring the operations, saw what happened or was able to react in time.

4.6 Working safely in the hatch crane danger zone

When there are people present in the path of the hatch crane while it is use, there are several control measures in place to mitigate the risk of someone becoming entrapped. The effectiveness of these control measures with regard to the six occurrences is described below.

Alarms
In all cases the hatch crane was fitted with acoustic and visual alarms to alert people of the danger posed by the moving hatch crane. Investigation identified that in four out of six instances the alarm must have been clearly audible for the victim, or that it must have been clearly noticeable that the hatch crane was moving. The fact that these accidents still could occur, proves that the control measure could not prevent them from happening. This can be explained by the fact that alarms are not a technical measure that can in itself physically prevent entrapment.

It is meant to increase the attention value by drawing the crew's attention to the moving hatch crane. In addition, using alarms as control measure has two limitations:

- The measure is aimed at the potential victim;
- Various circumstances in daily practice renders it less effective.

Aimed at the potential victim

To be effective, alarms are dependent on the actions of the potential victim. For various reasons it may be that people do not act as required (moving away from the danger) upon hearing the alarm. People working mainly in a dangerous setting can get used to the risks involved, causing them to consider the danger to be less serious. A high exposure to alarms can also lead to alarm fatigue, causing the reaction to be slower than required.

Limitations of control measures aimed at a potential victim

A soft measure cannot prevent an occurrence but can only contribute to risk control. Alarms are an example of this. When an alarm is effective and is being noticed by a potential victim, this person should still assess the situation himself or herself and bringing himself or herself to safety. Assessing the danger is made difficult because the danger in the working area is not necessarily acute and is not continuously present or present at fixed times. A hatch crane in operation is not always moving but sometimes stops to pick up or lower a hatch. This makes it harder for people to assess if it is safe for them to enter the crane path at a given moment. Added to this is the possibility that the hatch crane is not used at fixed times but also intermittently.

Although the investigations did not confirm with certainty that the victim made a wrong assessment or tripped, it does show this control measure to be vulnerable. People can make a wrong assessment, and the dynamic working environment (no fixed times, no continuous danger and ad hoc changes possible) increases the risk for doing so. Someone who has been warned for a danger can still make a wrong assessment or might be incapable of acting. Regarding the risk of entrapment this can have fatal consequences.

Reduced effectiveness

Apart from the fact that a warning does not always yield the desirable behaviour, it can also happen that the warning goes unnoticed. Concerning the 2018 occurrence on the Beauforce, the crew stated that there was much noise during the operations. A hatch crane is mainly used during the time a ship is berthed. During this time there may be much ambient noise, for instance during loading and unloading. The more ambient noise, the greater the odds are that an alarm will not be heard since it must compete with the ambient noise.

There are also specific circumstances that can limit the effectiveness of alarms. The improvised situation on board the Beauforce in 2018 was detrimental to the effectiveness of the alarm. This situation deviated from the normal operations whereby the alarm activated automatically and was clearly better audible in the gangway in comparison to the improvised installation on top of the hatch crane. In the case of the Toucan Arrow the acoustic alarm was inaudible from the victim's location and the visual alarm was defective.

Partial conclusion

In two of the six occurrences the victim probably did not notice the alarm. The investigative report for the four other occurrences stated that the victim should clearly have noticed that the hatch crane was moving. On the basis of the mentioned limitations it may be concluded that alarms when used as control measure do not constitute an adequate safety barrier.

Emergency stop button

In addition to alarms for warning potential victims the hatch crane should be fitted with an emergency stop button. Such a provision can at the last moment prevent an occurrence when timely activated. Paragraph 4.4 describes that in none of the occurrences there was someone present witnessing the accident or able to act in time to prevent it. This also means that no one other than the victim could have pressed the emergency stop button. In all six occurrences the emergency stop button as control measure was therefore aimed at the potential victim and suffers from the same limitations mentioned at alarms. An emergency stop button also has additional limitations.

Limited potential response

The emergency stop button can be pressed in case of imminent danger if (it seems that) someone will not be able to leave the danger zone in time. That leaves very little time to act when an emergency stop is necessary. The speed at which the hatch crane is moving is also a factor to reckon with; the slower it moves, the more time there will be to act. To that must be added that people will be able to adjust their assessment to the speed; the slower the hatch crane moves, the longer people think to be safe.

Emergency stop button not reachable

Apart from the limited potential response due to the limited time available, it also emerged that in five of the six occurrences the emergency stop button could not have been used by the victim since the distance was too great (in the case of the Toucan Arrow not investigated). In the case of the Lady Christina only the cable watch had an emergency stop at his disposal, but he had no view of the victim's location. In the other instances, the emergency stop was available to the victim but was only within reach from the gangway. The victims were higher up and could not reach the emergency stop button from this location.

Emergency stop button defective
After the occurrence on board the Beauforce in 2018, it emerged that the emergency stop button near the victim was defective, without this being known prior to the occurrence. Although the victim would not have been able to reach the emergency stop button, it is essential for a technical control measure to function properly and it should be known if it does. When technical control measures are defective, people will rely on a control measure that in reality is inoperative.

Risk increasing circumstances
Control measures that depend on action to be taken by a potential victim are particularly sensitive to circumstances effecting the operations. Some examples of such circumstances are external or self-imposed time pressure, the experience of the person in question or bad weather on board. When there is a physical separation between people and a moving hatch crane, these circumstances will not be of influence on the risk as errors will be eliminated.

When risk control focuses more on soft measures aimed at potential victims, the effect of the circumstances will be more prominent. People can make errors and the circumstances mentioned above will increase their likelihood. Someone experiencing time pressure will be more inclined to choose a faster but less safe option. Various cultural aspects may also apply, for instance when a deckhand does not dare to go against a superior, he will be more inclined to working unsafely. These circumstances are very diverse and may vary per individual and situation. In the case of the Karina C, at 09.00 hours local time the captain was told that the departure of his ship was brought forward by 2.5 hours to 11.30 hours because of the arrival of another ship. This meant that the crew was allowed only half the time originally planned.

Although it is important to work on improving working conditions, for instance by creating a better safety culture, it is important for risk management to tackle the risks at the source as much as possible. In this context the risk control is less dependent on people paying attention. Individual measures and personal protective equipment must only be used when control measures at a higher level are not feasible or if these do not offer sufficient protection.

Partial conclusion

The victim's action perspective when using an emergency stop button is limited and in many instances the emergency stop button was out of the victim's reach. On top of that, the emergency stop button on board the Beauforce in 2018 appeared to be defective. These observations cause the emergency stop button to have only limited effectiveness as a control measure.

Alarms and emergency stop buttons both are provisions that require action by potential victims which makes these provisions prone to error. This also entails that circumstances such as time pressure or bad weather have a larger impact on the effectiveness of control measures.

5 FINDINGS REGARDING THE SAFETY STRATEGY

This section describes the findings regarding the safety strategy. For this purpose the information of section 4 was compared with how similar risks are being managed.

5.1 Comparison with safety strategy for snap-back of mooring lines

There is a difference in risk approach when comparing the measures to control the risks involving a moving hatch crane with the measures to control the risks of mooring line snap-back. Just as is the case with a moving hatch crane, during mooring and unmooring there is no physical separation and it is necessary for the crew to be on deck. However, the control measures for both operations are different. Regarding mooring and unmooring, the manual *'That's right!'* devotes explicit attention to certain aspects:

- *Snap-back zones* must be clearly indicated and are off limits for everyone. It should also be taken into account that these operations may need to be carried out differently, sometimes causing the entire ship to become a possible *snap-back zone;*
- Actions may only be carried out by designated people;
- On board of every ship the tools for the job will be substantially the same, but will be different in detail. Therefore, it is important to look closely into the layout, operation and placement of the workplace and tools.

The respective safety strategies for mooring line snap-back and the use of hatch cranes are different in various aspects. For mooring and unmooring the importance of paying explicit attention to high-risk activities is emphasised. The same goes for clearly indicating the danger zone (*snap-back zone*) and temporal separation. This means that other ad hoc operations may not be carried out during mooring and unmooring. Although in practice this often still goes wrong, the consensus is that this is a high-risk operation and that the people on deck should not be involved in other operations. This constitutes a clear difference when compared to hatch crane operations. When operating and moving a hatch crane it is more usual for other people to carry out operations in the danger zone.

The third item in the above listing shows that it is important to look in detail into the differences in risk control. This is a valid and important point, as all ships are different and because of the different circumstances having an effect on this risk. Cargo type, weather conditions and material are a few examples. The manual 'That's right!' does not mention these circumstances in the section regarding the use of hatch cranes. The investigation showed that the hold entrance amidships is an example of a detail in the ship's design that is of influence on the risk of entrapment. It is important that such location specific attributes are included in the risk management objectives. This can be attributes related to the ship's design but also attributes that can be different for each individual cargo or situation. The attention to this with regard to the item of mooring and unmooring is justified and also seems justified for hatch crane operations.

Partial conclusion

The safety strategy with regard to mooring and unmooring shows both similarities and differences when compared to the risk management in place for preventing entrapment between hatch crane and ship. Mooring and unmooring is a high-risk activity and occurrences are still happening frequently. However, these can be used for future improvement. In this context, the importance of using danger zones and coordinating operations has been explicitly recognised. To a far lesser extent this applies to the use of hatch cranes, where it seems to be more accepted that operations are carried out in the danger zone without coordination.

5.2 Risk of entrapment is related to 'Line of Fire'

The risk of entrapment between hatch crane and schip is a risk involving a person getting into the *'line of fire'*; the risk arises when a person enters the danger zone. Apart from making the comparison with the risk approach for mooring and unmooring, it is therefore relevant to investigate how other sectors deal with the risk of people getting in the line of fire.

In various sectors, such as the petrochemical industry, *Life Saving Rules* were drawn up. These consist of a small number of rules that apply to everyone as they are considered to be essential for personal safety. The International Association of Oil & Gas Producers has designated *'Line of Fire'* as *Life Saving Rule* (see figure 19). Also other sectors, such as construction, have adopted (a variant of) this *life saving rule.*

It appears that various other sectors consider the risk of being in the *'line of fire'* to be unacceptable and recognise that risks are difficult to control when people are in the *'line of fire'*. People working in the *'line of fire'* are dependent on their own vigilance. An erroneous assessment can have fatal consequences for someone working in a danger zone such as the *snap-back zone* or the path of work traffic or a hatch crane. By prohibiting work to be carried out in the *'line of fire'*, this risk will be eliminated.

Figure 19: Life Saving Rule 'Line of Fire' as drawn up by IOGP. (Source: IOGP)

During the time of the investigation, the shipping industry also started an awareness campaign in an effort to contribute to safe working practices.[12] In this campaign there is explicit attention for hatch cranes and also for the importance of coordinating other operations that are carried out simultaneously. This is a positive development that will help to raise awareness of the danger of working in the *'line of fire'*.

Partial conclusion

Other sectors pay much attention to the risk of working in the *'line of fire'*. The petrochemical industry and construction industry are two sectors that have recognised the gravity of the risk of being in the *'line of fire'* by drawing up a *Life Saving Rule*. These sectors consider it an unconditional requirement to keep people from getting into the *'line of fire'*. With its awareness campaign, the shipping industry has taken an significant step towards recognising the risk.

The risk of entrapment is a risk that in current practice can be insufficiently managed. The high dependency on crane operators and potential victims paying close attention and taking action, are in stark contrast to the working practice used when mooring and unmooring and working in the *'line of fire'* in other sectors. As long as operations in the danger zone of the hatch crane are allowed, the risk of entrapment cannot be or can hardly be controlled.

12 Working safely at sea, 'Keep communicating when the hatches open', https://www.veiligwerkenopzee.nl/project/Luikenwagen/, last consulted on 07-03-2022.

6 CONCLUSIONS

Using five other fatal occurrences apart from the occurrence on board the Beauforce in 2018, this investigation analysed at the risk of entrapment and the effectiveness of the related control measures currently in place. The investigation shows that the risk of becoming entrapped or crushed between the hatch crane and parts of the ship is high. Controlling this risk largely depends on the actions of the people present. The risk of errors is further increased by the working conditions. The investigated occurrences illustrate that errors can have fatal consequences for people working in the close proximity of the hatch crane. If nothing changes, the risk of entrapment cannot be or can hardly be controlled. The starting point has to be that nobody will cross the hatch crane rails while the hatch crane is in use. If it is necessary to cross the rails, the hatch crane will not be moved.

6.1 The underlying factors that contributed to the occurrences

The way the risk of becoming entrapped was managed, identified the following underlying factors:

- The layout of the ships allows people to enter the path of the hatch crane.
- It appears that it is common practice to carry out both hatch crane operations and non-hatch crane operations at the same time in the close proximity of the hatch crane.
- In most cases the victim was not expected to be in the danger zone because he was carrying out operations not related to the use of the hatch crane.
- Several limitations create a situation in which the hatch crane operator is not sufficiently capable of preventing an entrapment.
    - The operator's view is severely restricted and does not allow him to have a proper overview of the crane path. This is the reason why he needs assistance to be able to operate the hatch crane safely.
    - Communication with others is essential when moving the hatch crane in order to be able to work safely. The occurrences show that there difference in interpretation may occur or that there is no communication at all.
    - Communication with people assisting the operator is a way of avoiding the problem of lack of communication with a potential victim. However, it appears that in all six occurrences there was nobody present that could have been able to act in time.

- Working safely in the danger zone of the hatch crane largely depends on the vigilance and the actions of a potential victim.
  - Alarms are aimed at alerting a potential victim, which makes it an instrument that is prone to error because circumstances such as time pressure and the victim's own interpretation are of influence.
  - The victim's action perspective when using an emergency stop button appears to be limited, and in many instances the emergency stop button was out of the victim's reach. The emergency stop button can also be defective without this being known.

6.2 Safety strategy

The Board concludes that in the current practice the risk of entrapment is not adequately controlled. Regarding mooring and unmooring and working in the *'line of fire'*, the importance of coordination has been explicitly recognised. It is necessary to improve the coordination of operations when operating the hatch crane. It is essential to have a clear framework and agreements with regard to operations being carried out simultaneously. Otherwise the risk of entrapment cannot be or can hardly be controlled. The starting point has to be that nobody will cross the hatch crane rails while the hatch crane is in use. If it is necessary to cross the rails, the hatch crane will not be moved.

7 RECOMMENDATIONS

Several initiatives to improve safety on board in general, and safe working with hatch cranes specifically, have been undertaken. The Safety Board considers such initiatives important. In addition to this the Safety Board issued the following recommendations:

To Vertom Shipmanagement b.v. and the Royal Association of Netherlands Shipowners:

1. During hatch crane operations the basic principle has to be that nobody will cross the hatch crane rails while the hatch crane is in use. If it is necessary to cross the rails, the hatch crane will not be moved.
2. Bring the risk of entrapment by hatch cranes further to the attention of the Dutch shipowners and point out the necessity of clear agreements with regard to operations being carried out in the danger zone. Make use of the experience of shipowners in defining the danger zone in relation to the hatch crane and in determining which activities should be allowed to take place in the danger zone and which should not be allowed.
3. Make clear agreements about the exact location of the danger zone in relation to the hatch crane and which activities need to be carried out in the danger zone during moving and working with the hatch crane.

To the Netherlands Maritime Technology and the Royal Association of Netherlands Shipowners:

4. Investigate together the possibilities to eliminate or reduce the risk of entrapment by hatch cranes from the design. Explicitly include:
   - The possibilities involving the design of the ship, both during the design of new ships as engineering opportunities on existing ships;
   - Methods to alert people on board of the ship of hatch crane operations in such way that it is clear when it is a direct danger for them.

APPENDIX A

VESSEL DATA

Ship's specifications	Beauforce
Photograph:	
Call sign:	PCHK
IMO number:	9526095
Flag state:	The Netherlands
Home port:	Sneek
Type of ship:	Fully cellular container ship
ISM administrator:	Focus Shipmanagement BV
Classification society:	Bureau Veritas
Year of construction:	2010
Shipyard:	Damen Shipyards Bergum
Length overall (LOA):	118.14 m.
Length between perpendiculars (LPP):	112.29 m.
Width:	15.9 m.
Draught:	7.2 m.
Gross tonnage:	5425

Ship's specifications	Beauforce
Engines:	MAK 9M25
Propulsion:	1 screw propeller – variable speed, 1 bow thruster
Maximum propulsion power:	2970 kW
Maximum speed:	12.9 knots
Ship's certificates:	All valid

COURSE OF EVENTS AND BACKGROUND INFORMATION ON BEAUFORCE 2018

This appendix describes the course of events on board of the Beauforce from the preparations prior to arrival in the port to just after the moment the hatch crane collided with the deckhand. The planning of the Beauforce in conjunction with the port authorities, the eventual arrival and the operations while berthed until the moment the accident occurred will all be looked into.

The Beauforce sailed from New York with a cargo of used cars to the port of St. Marc, Haiti. During the voyage the estimated arrival time was reported to the port authorities and it transpired that another vessel was expected to arrive at the same time. The port authorities advised to arrive as soon as possible in order to enable the ship to berth before the arrival of the other ship. This failed, and the Beauforce was forced to spend a night offshore before being allowed into port. Therefore, the ship arrived on 29 June 2018, one day later than planned.

In the afternoon of 29 June the crew started unloading the cargo. In this process, local stevedores operated the ship's crane as there were no quay cranes available. The work finished at 20.45 hours and the holds were closed at 21.00 hours. Around 06.20 hours the following day the holds were opened again and at 07.15 hours unloading resumed.

After the stevedores had left cargo hold no. 1, the boatswain (hereafter 'the victim') and the second deckhand (hereafter 'the operator') noticed that unloading hold no. 1 had almost been completed. The victim informed the first officer about this, upon which the first officer gave the order to check if hold no. 1 had been vacated. After the victim had done so, the first officer gave him the order to close hold no. 1 together with the operator. For this task the first officer allowed time until 08.20 hours, but the captain allowed some more time to ease the time constraint. Sometime later the victim asked the first officer to appoint an extra hand for assistance, upon which the first officer sent the third deckhand.

Visualisation of the situation

The construction of the hatch crane is such that the operator only has a restricted view of the starboard side, requiring assistance by a second person when operating the crane. The later victim asked if the third deckhand could assist him in closing the hold, with which the first officer agreed. The third deckhand was actually standing in the starboard gangway and had visual contact with the operator. The operator has practically no view of the port gangway and indicated that he could not see if the victim was there.

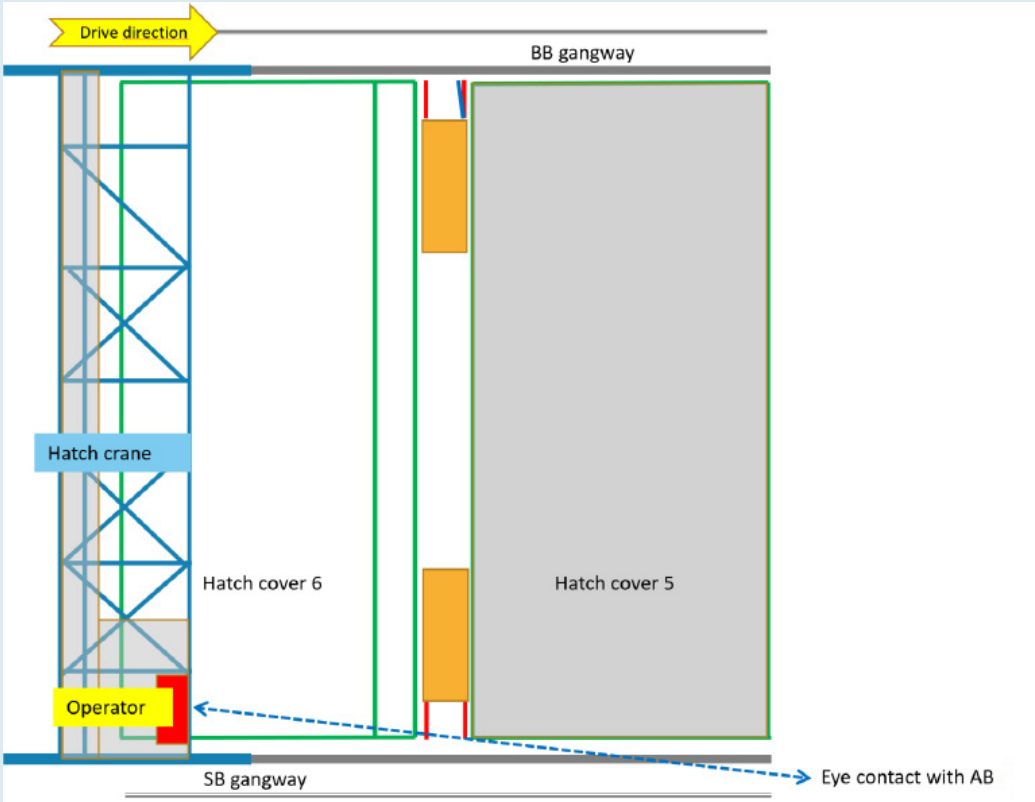


Figure 20: Top view direction of crane travel.

The operator went to the hatch crane and climbed on top of it. Because of a few degrees list to starboard, the operator first rotated the jibs of the ship's cranes towards the ocean (port side). Then the operator asked if it was 'clear' to move the crane. This was confirmed by both the third deckhand, standing on starboard side, and the victim, expected to be standing in the port side gangway - the location that was out of the operator's view. Later, it turned out that the victim was still on his way to the port side gangway via the hold entrance amidships.

Upon receiving the confirmation, the operator moved the crane in the direction of the bow for the purpose of closing the hold with the hatches. During the movement of the crane in the direction of the stacked hatches the victim became entrapped. This happened just in front of the hold entrance between holds no. 1 and 2. It is not possible to state with absolute certainty whether this occurred between the portal of the hatch crane and the watertight door or the stacked hatches.

A.1 Ship and crew

The Beauforce is in legal ownership of Unisea Shipping B.V., based in Sneek and from 1 February 2016 has been under operational management by Vertom-Bojen Bereederungs GmbH & Company KG. Vertom-Bojen has more ships under operational management.

The Beauforce was built in 2010 by Damen Shipyards Bergum and is of the type 'Damen Combi Freighter 8200'. The ship has been in worldwide use for various charters. The Beauforce is fitted with pontoons that can be installed both horizontally and vertically, enabling the holds to be arranged flexibly. Thanks to this feature, the crew can use the pontoons to adapt the layout of the holds as required, for instance to create a tweendeck or a bulkhead, enabling the ship to carry various types of cargo.

The minimum required crew (*'minimum safe manning'*) is eight. At the time of the accident, the crew of the Beauforce consisted of ten crew members of three different nationalities.

Position	Nationality	Location at time of occurrence
Captain	Filipino	On the bridge
First officer	Ukrainian	Near hold no. 2
Third officer	Filipino	In his cabin (rest period)
Chief Engineer	Russian	Engine room office
Third Engineer	Ukrainian	Engine room
Deckhand cook	Filipino	Galley
Deckhand 1/lead hand(AB)	Filipino	Victim, port side hold entrance amidships
Deckhand 2 (AB)	Filipino	Crane operator
Deckhand 3 (OS)	Filipino	Starboard gangway
Deckhand 4 (OS)	Filipino	In his cabin (rest period)

Table 3: Positions and nationality of the crew members of the Beauforce at the time of the occurrence.

The victim was an able-bodied seaman (AB). The crane operator also was an able-bodied seaman (AB). It was the victim's first contract on board the Beauforce. Both crew members were signed up on 11 May 2018.

The *Safety Management Certificate* of the Beauforce was certified by classification society BV Bureau Veritas on 31 August 2016, after the first fatal occurrence and valid until 21 July 2021.

APPENDIX C

RESPONSES TO THE DRAFT REPORT

In accordance with the Dutch Safety Board Act, a draft version (without recommendations) 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:

- Vertom shipmanagement b.v.
- Koninklijke Vereniging van Nederlandse Reders
- Australian Transport Safety Bureau
- Maritime Accident Investigation Branch

The responses received can be divided into the following categories:

- Corrections and factual inaccuracies, additional details and editorial comments that were taken over 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.
- Adopted responses; they are also listed 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).

RI&E BEAUFORCE, 2018

Verlom-Bojen Bereederungs GmbH & Co. KG	Risk Assessment	page	1 of 1

Assessed Risk: Hatch Cover Gantry Crane

Record Number: B 16

Assessment date: 16.04.2018 **Assessor:** K. Lampert

Detailed description of Risk: Stowage and operation of hatch cover gantry crane

Section 1

Hazard Analysis of the Risk

Hazard No.	Description of Identified Hazards	Existing Control Measures to Protect Vessel/Crew from Harm
1	Hatch cover gantry crane is not lashed in secure position before sea passage	(a) use of cargo operation checklist (b) use of departure checklist (c) confirmation by deck personnel to deck officer once crane is secured after use
2	Danger of wrong crane operation	(a) hatch coaming in way of crane track to be free of obstructions (b) crane only to be used by personnel who have received familiarization in the use (c) moving of crane always with 2 persons to monitor correct crane movement on both sides
3	Harm to other persons during crane movement	(a) verify that no personnel is in way of crane movement (b) working crane alarms during moving (bell) (c) working crane lighting (e.g. ps, stb, center - as manufactured) (d) working emergency stop of crane
4		(a) (b)
5		(a) (b)

Section 2

Assessment of Risk Factor

Likelihood of Harm	Severity of Harm		
	Slight Harm	Moderate Harm	Extreme Harm
Very Unlikely	VERY LOW RISK	VERY LOW RISK	HIGH RISK
Unlikely	VERY LOW RISK	MEDIUM RISK	VERY HIGH RISK
Likely	LOW RISK	HIGH RISK	VERY HIGH RISK
Very Likely	LOW RISK	VERY HIGH RISK	VERY HIGH RISK

Hazard No.	Likelihood of Harm	Severity of Harm	Risk Factor
1	VU	MH	VLR
2	VU	MH	VLR
3	VU	MH	VLR
4			
5			
6			
7			
8			
9			
10			

To assess the risk factor arising from the hazard:

1. Select the expression for likelihood which most applies to the hazard;
2. Select the expression for severity of harm which most applies to the hazard;
3. Cross reference using the Risk Estimator table (above left) to determine the level of risk;
4. If the Risk Factor is Medium or above (Yellow, Orange or Red) additional control measures should be implemented and recorded in Section 3.

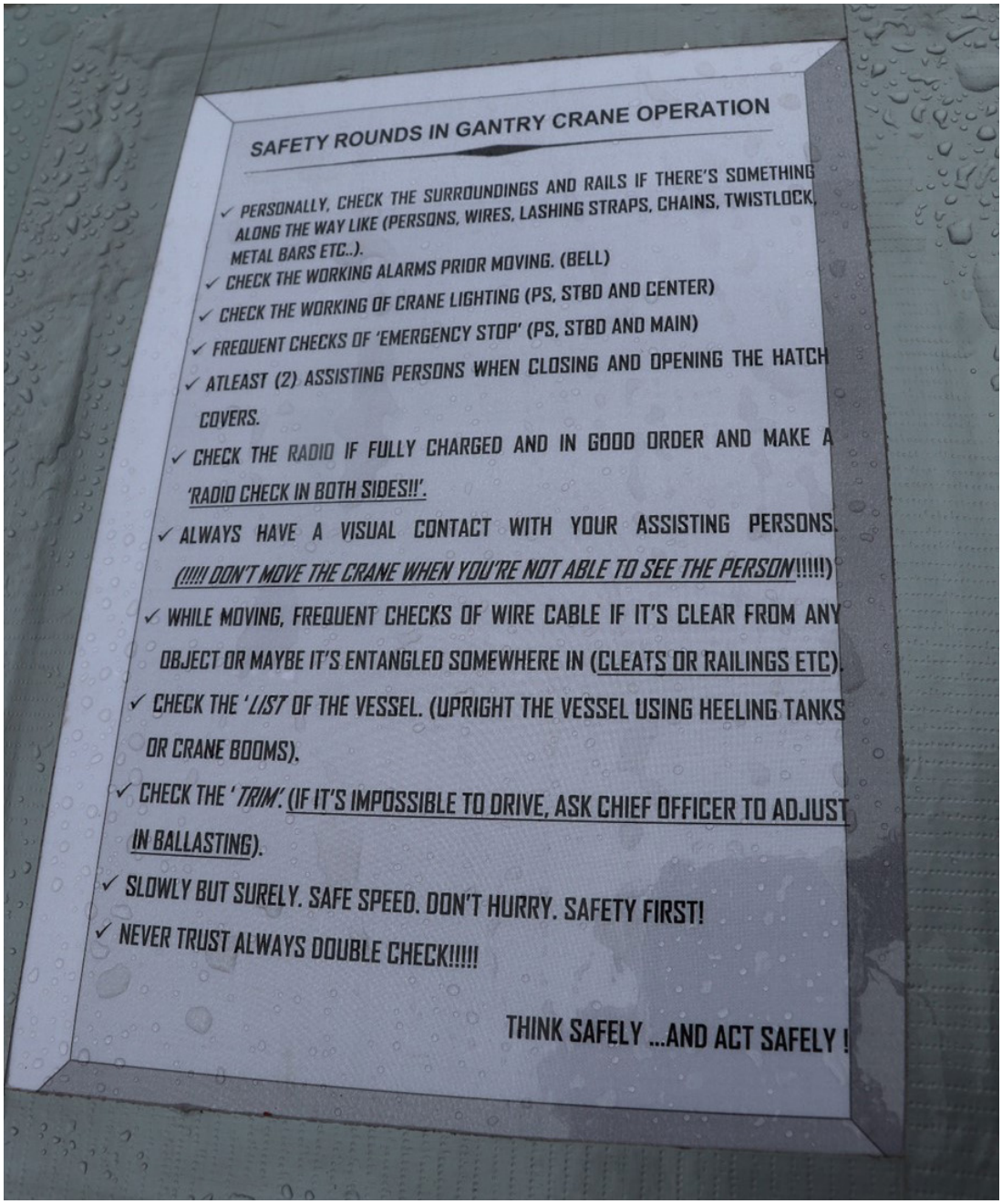
Section 3

Additional Control Measures to Reduce the Risk of Harm

Hazard No.	Further Risk Control Measures
1	
2	
3	
4	
5	

Signature Assessor: _____

OPERATOR INSTRUCTIONS



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