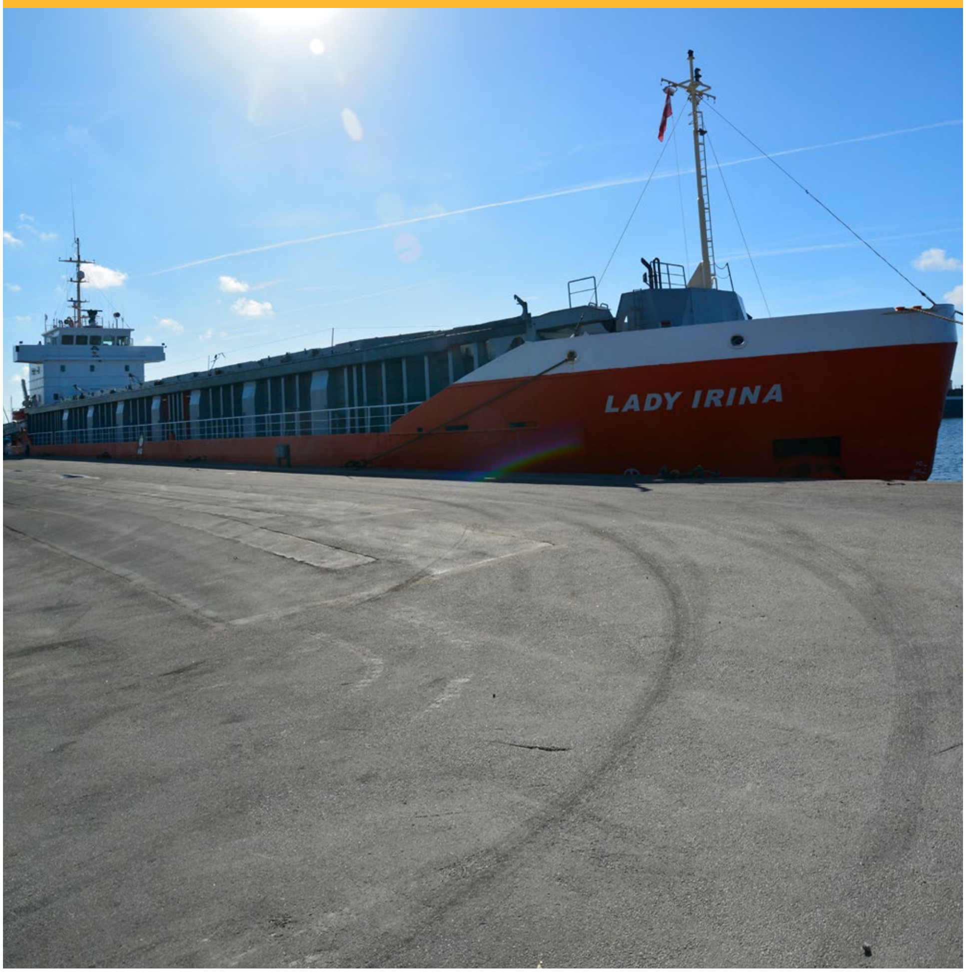
DUTCH
SAFETY BOARD

Carbon monoxide in bow thruster room



Carbon monoxide in bow thruster room

The Hague, November 2015

Source photo cover: Dutch Safety Board

Dutch Safety Board

The aim in the Netherlands is to limit the risk of accidents and incidents as much as possible. If accidents or near accidents nevertheless occur, a thorough investigation into the causes, irrespective of who are to blame, may help to prevent similar problems from occurring in the future. It is important to ensure that the investigation is carried out independently from the parties involved. This is why the Dutch Safety Board itself selects the issues it wishes to investigate, mindful of citizens' position of dependence with respect to authorities and businesses. In some cases the Dutch Safety Board is required by law to conduct an investigation.

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NB: This report is published in the Dutch and English languages. If there is a difference in interpretation between the Dutch and English versions, the Dutch text will prevail.

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INTRODUCTION

On 13 July 2014 the chief engineer of the Lady Irina, a Dutch registered motor vessel, died after entering the bow thruster room. The coroner determined that the chief engineer died from carbon monoxide poisoning.

This concerns a very serious accident as referred to in the International Maritime Organization's (IMO) Casualty Investigation Code and EU directive 2009/18/EG. This means that the Netherlands, as the vessel's flag state, is obliged to ensure that a safety investigation is conducted. This statutory investigation duty is also set out in the Dutch Safety Board Decree (Besluit Onderzoeksraad voor Veiligheid).

Following the accident, investigators from the Dutch Safety Board went on board the vessel to conduct an investigation. This report describes the relevant facts of the incident and examines the direct and underlying causes of this.

The Dutch Safety Board has also conducted a thematic review of carbon monoxide accidents predominantly in the home environment. The results of this will be announced soon and will be published in a separate report.

RELEVANT FACTS AND BACKGROUND INFORMATION

Figure 1: Lady Irina. (Source: Dutch Safety Board)

Vessel specifications - Lady Irina	
Call sign:	PEVE
IMO number:	9137038
Flag state:	The Netherlands
Home port:	Delfzijl
Vessel type:	General cargo with container capacity
Shipping company:	Wijnne Barends
Owner:	B.V. Beheermaatschappij Irina II
Classification society:	Lloyd's Register
ISM:	Lloyd's Register
Year of build:	1997
Shipyard:	Royal Niestern Sander b.v.

Vessel specifications - Lady Irina	
Length overall (LOA):	88 metres
Breadth:	14.4 metres
Draught:	5,89 meter
Gross Tonnage:	3323GT
Engines:	1 * Diesel Caterpillar (main engine)
Propulsion:	Single variable-pitch propeller
Maximum propulsion power:	2460kW
Maximum speed:	13.5 knots

Relevant facts

Accident

On 5 July 2014, Lady Irina left the Port of Arkhangelsk (Russia) with the purpose of unloading a cargo of wood pellets in Kolding (Denmark) on Sunday 13 July. Arkhangelsk is Lady Irina's permanent loading port for this cargo and has a dozen discharge ports in Europe, of which Kolding is one.

The crew followed the daily routine on board during the period at sea. The bow thruster room and forecastle were entered and left regularly, which is why the doors of the forecastle and bow thruster room were left open during the day. Also on Saturday 12 July various crew members entered the forecastle and bow thruster room to collect tools and mix paint. The doors were closed once work ended on Saturday at 17:00 hours.[1]

The following evening, on Sunday 13 July, the crew prepared for Lady Irina's arrival in the Port of Kolding. At 19:00 hours the chief engineer visited the bridge where the chief officer was on watch.

They had a cup of coffee and discussed draining[2] the chain locker before Lady Irina arrived at the port in connection with a draught survey[3] that would be conducted to read the vessel's draught marks. During a week at sea, for this ship, it is normal for seawater spray from oncoming waves to enter the chain locker. The water in the chain locker increases the vessel's draught, which can be read from the draught marks.

Between 19:30 and 19:45 hours, the chief engineer left the bridge and went to the engine room. This was approximately four hours before the vessel would be moored in Kolding.

1 All times stated in this report are local times.
2 Pumping water overboard using a bilge pump.
3 Draught survey: a method to calculate the quantity of dry bulk cargo being unloaded by a vessel and to compare this with the quantity stated on the cargo documentation. In the calculation the ships' displacement is used and therefore the vessels draught is determined. The draught is determined using the draught marks. The amount of water influences the draught, which is why, prior to arrival in port, water is pumped out of the chain locker.

After the captain took the watch on the bridge at 20:00 hours, the chief officer went to the chief engineer's cabin. The chief engineer and chief officer met every day at this time to discuss the work to be carried out on the vessel the following day. As the chief engineer was not in his cabin, the chief officer went to his own cabin to watch television. The chief officer was not surprised that the chief engineer was not in his cabin as it was likely that the chief engineer still had other duties to perform in connection with the imminent arrival at the port.

At 21:45 hours, the chief officer went to the chief engineer's cabin once more, but the chief engineer was still not there. The chief officer then went to the engine room. The chief engineer was not there either. In the engine room the chief officer saw that the ballast pump was being used to drain the chain locker. He found this strange as pumping out the chain locker would normally take no more than 20 minutes. That is why the chief officer went to the forecastle. The forecastle is located in the bow of the Lady Irina.

The chief officer found the forecastle door open and, on entering the forecastle, found the chief engineer a deck lower on the floor of the bow thruster room. On examination he found that the chief engineer was not breathing and had no heartbeat. The chief officer went to the bridge to alert the captain and to summon assistance.

Rescue operation

At approximately 22:00 hours, the captain and second mate were on the bridge when the chief officer came to report that he had found the chief engineer in the bow thruster room. The chief officer ordered the second mate to go to the accident site with a stretcher.

The captain decided to sail as quickly as possible to the Port of Frederica (Denmark, approximately 4 nautical miles[4] from Lady Irina's then position). He contacted the ship's agent to report the arrival of Lady Irina and to ensure that the ship's agent would alert the local emergency services so that they would be present once the ship arrived at the quayside.

After alerting the captain and second mate, the chief officer went to the crew accommodation to alert the rest of the crew and directed them to the bow thruster room. He put on work clothing in order to lead the chief engineer's rescue operation.

A few minutes later, the chief officer again arrived in the bow thruster room. The alerted crew members had already started the rescue operation. They tried to resuscitate the chief engineer. Initially they did not use the breathing apparatus that they had taken with them because they thought that the chief engineer had fallen from the ladders and that air quality was not the problem.

At that time all crew members except the captain were involved in the rescue operation in the bow thruster room. This involved six crew in total: the first and second mates, the apprentice engineer, the cook and two seamen.

4 1 nautical mile = 1.852 km.

Around 22:45 hours the vessel arrived in the Port of Frederica and the captain started the berthing process. As he needed the bow thruster for this, which needs to be started in the engine room, the apprentice engineer and a seaman left the bow thruster room to go to the engine room.

When it became clear that it would not be possible to lift the heavily-built chief engineer out of the bow thruster room on the stretcher, the second mate also left the room to collect a neck brace and oxygen kit. He collected the neck brace because the crew thought that the chief engineer had fallen from the ladders. The second mate also collected the medical oxygen kit, which is always present on a vessel and is used to administer oxygen in the event of incidents, because the chief engineer was not breathing.

When the second mate returned to the bow thruster room a few minutes later he saw the chief officer unconscious on the floor, a crew member trying to carry him away and another seaman walking around as though drunk. The second mate went inside, placed the breathing apparatus on the chief officer's mouth and noticed it worked. He also urged the two other crew members to leave the room. He then left the bow thruster room and forecastle because he did not feel well. After the second mate left the bow thruster room he opened the medical oxygen kit and lowered it with a rope, in order to generate extra oxygen in the room. Thereafter he assisted on deck with berthing the vessel.

When the vessel entered the port, the apprentice engineer, a seaman and the second mate were available on deck to ensure that the vessel could berth. The other crew members were unable to assist. The chief officer was unconscious. The other two crew members, who had by now managed to get outside, were weakened to such an extent that they could not be deployed.

The vessel berthed at 22:50 hours and the local (Danish) fire service came on board. They carried the chief engineer and the chief officer outside the bow thruster room. The chief officer had been given oxygen and later regained consciousness on deck.

A coroner ascertained that the chief engineer had died from carbon monoxide poisoning. Three other crew members (the chief officer and two seamen) were admitted to hospital and were allowed to return on board after a few days. All were diagnosed with carbon monoxide poisoning.

ANALYSIS

This chapter describes the direct causes, circumstances and underlying causes of the accident as these emerged during the investigation. To clarify the circumstances and underlying causes of this accident, an explanation is given as to how carbon monoxide can enter the bow thruster room. Next, the daily use of the forecastle and bow thruster room and the risks of the cargo being transported by Lady Irina are analysed. Finally, this chapter examines the rescue operation that followed the discovery of the chief engineer and the measures that the shipping company has taken as a result of this accident.

Bow thruster room and forecastle
The bow thruster room and forecastle are areas that are entered regularly on board most vessels. This was also true on board Lady Irina. Maintenance equipment, safety equipment and the emergency firepump are located in the bow thruster room and in the forecastle.

The bow thruster room on board Lady Irina is located beneath the vessel's forecastle deck between the ballast water tank and directly under the forecastle. The bow thruster room can only be approached via the forecastle and has no door to the outer deck (see figure 2).

Neither the forecastle or bow thruster room have mechanical ventilation.

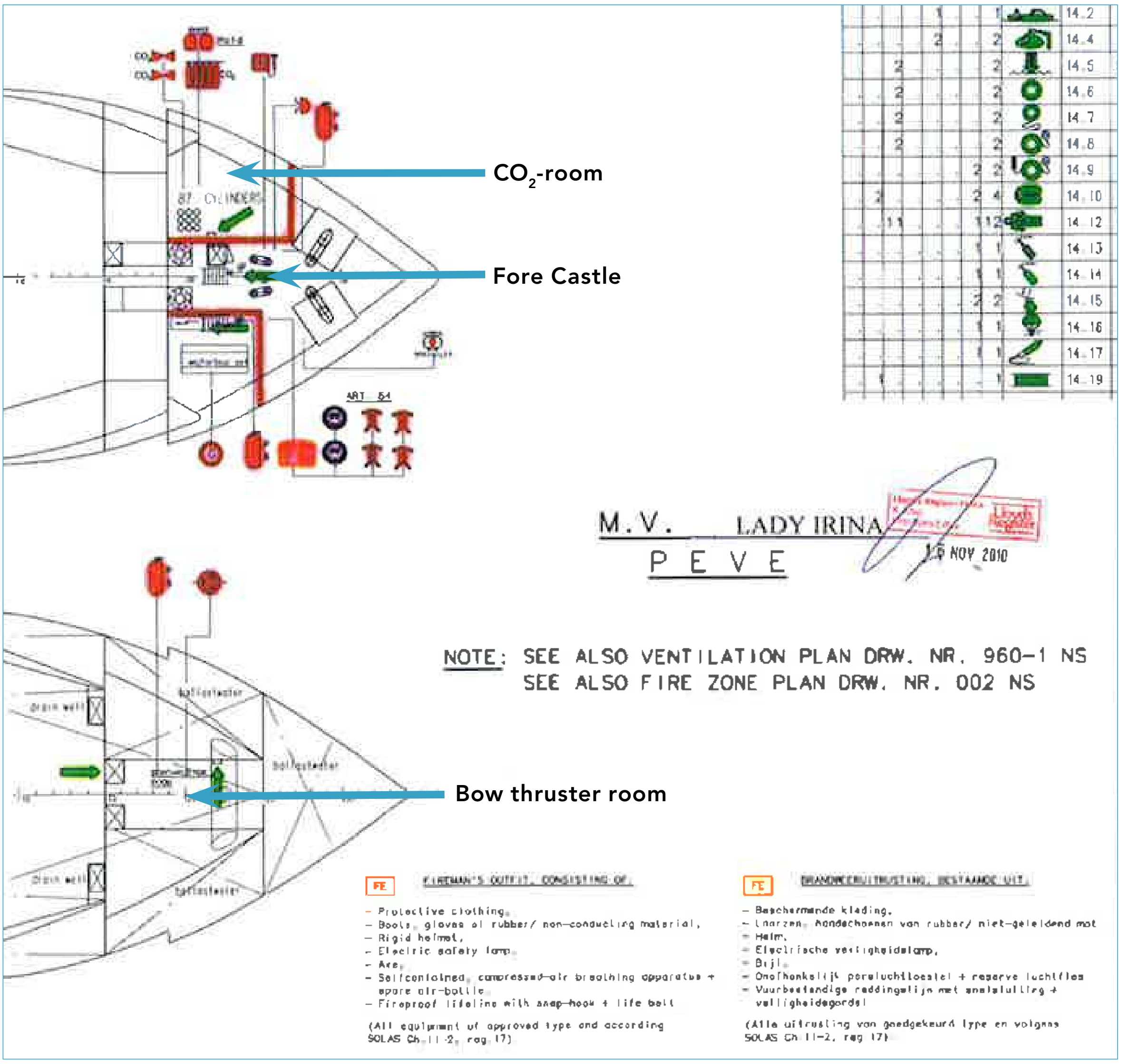

Figure 2: Lady Irina forecastle. (Source: Wijnne Barends shipping company)

Direct cause

The direct cause of the death of the chief engineer is carbon monoxide poisoning, which he sustained on entering the forecastle and then the bow thruster room briefly in order to be able to pump water from the chain locker. The chief engineer was not wearing overalls when discovered, which suggests that he only expected to be in the bow thruster room for a short time; he generally wore overalls when performing his duties.

Prior to entering the bow thruster room, the chief engineer consulted the chief officer during a discussion on the bridge. After this, he worked alone. It can no longer be determined whether the chief engineer ventilated the forecastle and bow thruster room before he entered. It is also no longer possible to determine why he did this work alone.

Carbon monoxide leak

After the accident the Danish fire service measured carbon monoxide (CO) levels in the air in the bow thruster room and tank. The fire service took the first measurement after the accident when both spaces had been ventilated for an hour and a half using electric ventilators installed by the fire service. At that time the measured values in the forcastle were 80 ppm[5] CO and 20 ppm CO in the bow thruster room. The fire service repeated the measurement after keeping the forcastle and bow thruster room closed for 36 hours. 690 ppm CO was measured in the forcastle and 555 ppm CO in the bow thruster room. During this measurement the fire service also measured the CO levels in the CO_2 room[6]; more than 2,000 ppm CO was measured there (above the maximum that could be measured by the measurement equipment). After the cargo of wood pellets was unloaded, no more carbon dioxide was detected in the bow thruster room, the forcastle or the CO_2 room (see paragraph 'Cargo' on page 14).

The measurements taken after the accident were taken in a situation comparable to the evening that the chief engineer entered the tank and bow thruster room. The forcastle and bow thruster room had been closed for more than 27 hours when the chief engineer entered. In that 27 hours the concentration of carbon monoxide became too high for a person to remain there safely for a longer period of time (see table 1).

	Appearance of first complaints (HbCO[7] level 5%)		Appearance of serious complaints (HbCO level 20%)	
At rest	50 ppm 100 ppm 250 ppm	7 hours 2.5 hours 1 hour	- - 250 ppm 500 ppm	- - 4.5 hours 2 hours
Light exertion	50 ppm 100 ppm 250 ppm	5 hours 1.5 hours 30 min.	- - 250 ppm 500 ppm	- - 3.5 hours 1 hour
Strenuous exertion	50 ppm 100 ppm 250 ppm	2.5 hours 1 hour 15 min.	- - 250 ppm 500 ppm	- - 2 hours 30 min.

Table 1: Relationship on the one hand between CO concentration, time and level of exertion (together with dose) and on the other the occurrence of health symptoms (rough indication). (Source: Kerkhoff R.L.H. e.a. (2008), G.G.D. richtlijn medische milieukunde: koolmonoxide in woon- en verblijfsruimten)

The CO_2 room, forcastle and bow thruster room are adjacent to each other in the bow and there are various conduits between theses rooms, which means that air can circulate and be distributed in the bow from one area to the other if these conduits are not sealed air tight. The only entrance to the bow thruster room is the hatch from the forcastle. The hatch was opened regularly.

5 Ppm: parts per million: in this case the number of millilitres of carbon monoxide per litre of air.

6 The CO_2 room is located next to the forecastle, see figure 2. An extinguisher system is located in the CO_2 room, which is intended to extinguish any fire in the cargo hold by filling the cargo hold with carbon dioxide (CO_2).

7 HbCO level: Carbon monoxide is rapidly absorbed by the lungs into the blood. In the blood it penetrates the red blood cells and binds to the protein haemoglobin. Normally oxygen binds itself to haemoglobin for transport through the body. Carbon monoxide, however, binds itself an estimated 230 times faster to haemoglobin than oxygen. This means the carbon monoxide takes the place of oxygen and is transported throughout the body. The parts of the binding sites for oxygen that are occupied by carbon monoxide depend on the level of exposure (the level of carbon monoxide in the air) and the duration of exposure. The higher the exposure and the longer the exposure lasts, the more binding sites will be occupied. This is expressed as a percentage: the % of HbCO (carboxyhaemoglobin) indicates the percentage of binding sites that are occupied.

The air from the cargo hold can have reached the bow (forecastle, CO_2 room and bow thruster room, see figure 2) in a number of ways:

- The CO_2 room is connected to the cargo hold via CO_2 extinguishing pipes;
- The pipes from the bilge system travel both through the cargo hold as well as through the forecastle and bow thruster room;
- Ventilation ducts run to the outside from the cargo hold via bow thruster room and the forecastle;
- The bow thruster room borders the hold directly via the foremost bulkhead.

During the investigation[8] a gap was determined in the inspection hatch on a ventilation duct that runs from the cargo hold through the forecastle (see figure 3). The largest proportion of carbon monoxide probably entered the forecastle via this gap. The cargo of wood pellets that produced the carbon monoxide was stored in the cargo hold. The hold was not ventilated, which meant that carbon monoxide levels were able to rise and ultimately enter the forecastle via the gap in the ventilation duct. Carbon monoxide was able to spread further to the bow thruster room via air circulation through the hatch from the forecastle. The investigation did not demonstrate that carbon monoxide also entered the forecastle via the other routes, but this possibility exists as no single route can be guaranteed as entirely air tight.

Figure 3: Gap in inspection hatch cargo hold ventilation duct forecastle. (Source: Lloyd's Register EMEA Denmark)

8 Following the accident, the classification society, contracted by the shipping company, investigated how carbon monoxide could have entered the bow thruster room.

Use of the bow thruster room and forecastle

Confined space
The procedure for entering a confined space has been developed to reduce the risk of entering a confined space that has potentially hazardous air.

According to the shipping company's 'Fleet Manual' the definition of a confined space is as follows:

'A confined space is an area in which there are limited openings for entering or leaving, in which there is insufficient ventilation and that is not designed for continuous work. Such spaces include cargo holds, double hull spaces, fuel tanks, etc. and adjacent linked spaces.'

With this definition the 'Fleet Manual' follows the International Maritime Organisation (IMO) guideline as articulated in 'IMO Resolution A. 1050(27), 2011'.

On entering a confined space a lack of oxygen should be taken into account, with possible toxic air and/or possible explosive atmosphere, which is why the 'Fleet Manual' includes a procedure for entering a confined space. In summary the following rules apply:

- The captain identifies the necessary safeguards (ventilation, measurements to be taken) and ensures that an Entry Permit is issued.
- The responsible officer ensures that the correct personal protective equipment and communications aids are used and that an entry permit is formulated and signed by the captain.
- At least two people must work together, one to retain oversight and the other to perform the work.
- The space must be ventilated and then measured for sufficient oxygen and other toxic and explosive gasses.

As the cargo hold atmosphere can reach the bow compartments (the bow thruster room, forecastle and CO_2 room) via various routes, the cargo that Lady Irina transported - wood pellets in solid bulk[9] - can be hazardous.

The access from the forecastle and the access from the bow thruster room were therefore also provided with warning stickers that warn for the possibility of low levels of oxygen in the atmosphere.

9 Solid bulk cargo: Every cargo, other than liquids or gases, comprising a combination of particles, grains or larger items of material, usually of an equal composition, which are loaded directly into the storage hold of the ship without any form of intervening packaging (IMSBC Code Regulation 1-1 para 2).

Figure 4: Warning stickers entrance to tank and bow thruster room. (Source: Wijnne Barends)

Working method for using the bow thruster room and forecastle
The Lady Irina crew did not use the procedure for entering a confined space when entering the bow thruster room or the forecastle. In practice the crew opened the door of the tank and bow thruster room to ensure natural ventilation. They left the door open for 15 to 20 minutes before entering the room. During the day, if the room was entered frequently, the door remained open. The air was not measured for lack of oxygen and other toxic and explosive gases.

This accident shows that no connection was made between the potentially hazardous atmosphere in these areas and the use of these areas. This risk increases if rooms are entered at other moments than during the working day, because the atmosphere has then not been refreshed by (natural) ventilation for a longer period. This situation applied to the chief engineer on the Sunday evening when he, operating alone, went to check the water in the chain locker.

The forecastle and the bow thruster room were entered using a shortened procedure (15 to 20 minutes natural ventilation), as the crew were under the impression that this was enough to manage the risks associated with a hazardous atmosphere. The crew did not consider the risks in the forecastle and bow thruster room to be of such nature to warrant carrying out the entering a confined space procedure. The use of a confined space procedure did not fit with the daily and frequent use of the forecastle and bow thruster room.

Risks of cargo, control measures and legislation

The cargo

The cargo that Lady Irina transported - wood pellets in solid bulk[10] - can be hazardous as it influences the ambient air of the hold. The International Maritime Solid Bulk Cargoes (IMSBC) code applies to this load. The cargo schedule from the IMSBC code indicates hazards in transporting this cargo as being that shipments could be prone to oxidisation, which leads to oxygen deficiency and an increase in carbon monoxide and carbon dioxide in cargo holds and thus in connecting spaces.[11]

An extra risk of this type of wood cargo is that the increase in carbon monoxide is accompanied by a slow reduction in the oxygen percentage, which makes the effect of carbon monoxide not immediately noticeable. When an O_2 meter measures the oxygen percentage in the air, the normal values are around 21%. The risk is that the person measuring then assumes that the air in the space to be entered is safe. However, at the same time it can be the case that sufficient carbon monoxide is present in the air to cause poisoning. Measuring only with an O_2 meter can give a false sense of safety.

Physical symptoms that can indicate carbon monoxide poisoning include pressure in the head, headache, 'heavy stomach', dizziness, nausea, tiredness, loss of concentration and irritability. Several of these symptoms were visible in the crew members that were involved in the rescue operation.

Table 1 gives a rough indication of the carbon monoxide concentration, the time of exposure and a person's exertion while being exposed to carbon monoxide. It gives a rough indication because the appearance of physical complaints depends on the person and situation.

Control measures cargo hold and connected areas

To protect personnel and cargo, various control measures must be implemented in accordance with the IMSBC code.

The cargo hold in which the cargo is stored qualifies as a hazardous space, but the adjacent spaces are also mentioned specifically. The IMSBC code schedule for wood pellets states: all crew members must carry an oxygen and carbon dioxide meter and switch this on when they enter the cargo hold or adjacent confined spaces.

The cargo hold must remain closed and may not be ventilated during the journey. Checks on the cargo take place during loading, after which the deck hatches of the cargo hold should be closed and the seams sealed. The deck hatches should only be opened again for unloading. The cargo hold may in principle not be entered during the journey, unless this is absolutely necessary, for example in the event of incident.

10 Solid bulk cargo: Every cargo, other than liquids or gases, comprising a combination of particles, grains or larger items of material, usually of an equal composition, which are loaded directly into the storage hold of the ship without any form of intervening packaging (IMSBC Code Regulation 1-1 para 2).

11 Source: IMSBC code, cargo schedule wood pellets.

The crew and the cargo
The crew of the Lady Irina was informed of the risks of this cargo. The shipping company uses Lady Irina regularly for transporting wood pellets with the above-stated properties. The journey between Arkhangelsk and Kolding also took place regularly with this specific cargo. The crew knew that the hold should not be entered and that the hold was sealed according instructions (hatches closed, seams sealed and ventilation openings closed from the hold). Each new crew member had received safety instructions. During this instruction attention was paid to such things as confined spaces and ventilation of holds in connection with possible lack of oxygen and other dangerous substances that emerge as a consequence of cargo. Also during the safety committee meetings attention was paid to entering confined spaces.

Rescue operation

During the rescue operation the crew was not aware of what caused the chief engineer to be lying on the floor of the bow thruster room. The chief engineer lay at the bottom of the ladders that led from the forecastle down to the bow thruster room. It was assumed that the chief engineer had fallen here, possibly partly because of a heart attack. Initially the crew members noticed nothing about carbon monoxide in the ambient air during the rescue operation. They were present for several minutes in the forecastle and bow thruster room without being hindered physically.

The crew did not consider that someone could be a victim of carbon monoxide poisoning in the bow thruster room. The crew made no connection between the incident and the nature of the forecastle and bow thruster room as rooms with potentially hazardous atmosphere. Proof of this is the way in which they used the bow thruster room (and forecastle) on a daily basis. Their entrance during the rescue operation confirmed this.

When the victim was found, the crew made no plan or did any preparation for the rescue operation. The first response on finding a victim was to start helping straight away. The crew had the impression that the victim fell of the ladder under which they found him and did not think of other scenario's, such as carbon monoxide poisoning. This is why, during the rescue operation, also other crewmembers were affected by carbon monoxide poisoning.

On board a vessel the crew cannot rely on assistance from emergency services to handle an incident. When a vessel is at sea, the crew must be self-reliant. This accident shows that for this kind of incidents it is important that the crew think first of their own safety, estimate the possible risks, discuss and share tasks between the crew, ensure that the correct personal protective equipment is available and then start with the real assistance. If taking such a hazard into account is part of the standard incident handling preparation, one may think, for example, of taking a multi-gas meter with them during a rescue operation.

Measures taken by the shipping company following the accident

To allow the vessel to continue sailing, the shipping company had extra multi-gas meters installed on board Lady Irina and after unloading the cargo conducted new measurements in Lady Irina's forecastle. These measurements indicated normal values.

To learn lessons from this the shipping company has discussed the events of this accident during safety committee meetings[12] on all vessels that it manages.

The shipping company has noted that it needs to focus extra attention on existing working methods for connected spaces in which a hazardous atmosphere could be created. That is why after the accident the shipping company developed a new working method for the entire fleet to prevent this kind of accident occurring in the future. In developing these working methods, the feasibility of the working method in daily practice on board was examined.

The working method concerns a 'First Entry'. 'First Entry' means the 'first' entry of a space on board a ship after it has been closed. The working method states that the person making the 'First Entry' must carry an operational multi-gas meter. This multi-gas meter gives an alarm signal when a concentration of hazardous gas is measured or if there is a lack of oxygen in the air. To be able to implement this, the shipping company has ensured that each vessel has at least three multi-gas meters available. This working method applies to the cargo hold and the adjacent spaces. On the Lady Irina, the forecastle and bow thruster room fall under this.

The shipping company uses a new sign for this working method (see figure 5). This sign has been placed on all accesses from the external deck to the hold and to the adjacent spaces on board all the shipping company's vessels. This contains a warning that an area is being entered in which there is a possible hazard for lack of oxygen or hazardous gases. The sign states that it is forbidden to enter the area for the first time without a multi-gas meter.

The shipping company has actively brought this working method to the attention of crew on all its vessels. The land-based staff of the shipping company's safety department visited the vessels to explain why this new working method was being introduced. During information days, attention was also focused on this new working method and on this accident, which was the reason for introducing this working method.

12 Holding monthly safety committee meetings is an obligation recorded nationally in the Shipping Act (art 26th paragraph 1) in accordance with the International Labour Organisation (ILO) treaty.

Figure 5: Sign regarding new working method. (Source: Wijnne Barends)

The new working method shows that the shipping company has incorporated the lessons learned. It is clear that both the confined space procedure, established for spaces with a potentially hazardous atmosphere, as well as the working method used by the crew, offer insufficient risk management for entering the forecastle and the bow thruster room. The new working method is a first step to make the daily use of connected spaces safer. It is, however, important to monitor how the new working method is implemented on board the ships. For example, the description of what is meant by a 'First Entry' can be interpreted in various ways. Furthermore, the use of a multi-gas meter demands discipline from the crew. The multi-gas meter needs to be checked and calibrated regularly to guarantee proper operation and the crew must understand how the multi-gas meter works (interpreting the measurements, being informed of the thresholds of the measured substances). The new working method must be evaluated and, based on the evaluation, improved where necessary.

CONCLUSIONS

The cargo on board Lady Irina produced carbon monoxide that could have leaked into the forecastle via various routes from the cargo hold. Probably the largest proportion of the carbon monoxide entered the forecastle via a gap in the cargo hold ventilator duct's inspection hatch and then into the bow thruster room. As the bow thruster room and forecastle had not been ventilated for more than 24 hours, carbon monoxide levels had increased. The chief engineer was exposed to high concentrations of carbon monoxide in the holds, which led to carbon monoxide poisoning.

The risk of the forecastle and bow thruster room atmosphere being hazardous was estimated as low and daily practice was adjusted accordingly; the areas were not treated as confined spaces. The daily practice on board on entering the forecastle and bow thruster room was adapted in accordance with the nature and daily use of the areas and was not based on a well-founded estimate of the risks.

Also from the actions during the rescue operation it appears that no connection was made between the (potentially) hazardous atmosphere in the bow thruster room and forecastle and the incident. This accident could have easily resulted in more victims of carbon monoxide poisoning.

The shipping company has provided the impetus to continue the working method used in practice by developing a new procedure that connects to this. The Board is of the opinion that, in the light of this accident, it is good that the shipping company examines the working method that was common in practice. However, the new working method desires focus on definition and crew discipline during use. The working method should also be evaluated and improved, where necessary.

LESSONS

1. A space that has been closed for a longer period should be entered with extra care. The confined space procedure, which is actually intended for entering such spaces, was not used by the crew. Natural ventilation prior to entering the forecastle and bow thruster room is a pragmatic solution. The extent to which such a solution offers sufficient risk management should be evaluated.
2. A rescue operation should be well prepared prior to commencing assistance. People who do not work safely during incident management will be unable to bring others to safety. At sea a ship's crew must be self reliant in managing any incidents.

APPENDIX A

REVIEW

In accordance with the Dutch Safety Board Act, a draft of this report was presented to the following parties:

- Wijnne Barends Cargadoors- en agentuurkantoren B.V.
- Danish Maritime Accident Investigation Board.
- 'Lady Irina' crew members that had been involved.
- These parties were asked to check the report for factual inaccuracies and ambiguities.
- All comments have been processed in the report.

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