Marine Safety Investigation Unit

Transport Malta

SAFETY INVESTIGATION REPORT

201108/028 REPORT NO.: 10/2012 August 2012

This safety investigation has been conducted with the assistance, full cooperation and jointly with the Marine Accident Investigation Commission of the Ministry of Transport, Maritime Affairs and Communications of the Republic of Turkey.

MV KAROLINE
Fatality of a crew member
At Aliaga Port, Turkey
23 August 2011

SUMMARY

On 23 August 2011, MV *Karoline*, a Maltese registered general cargo, was moored alongside in the port of Aliaga, when one of the crew members was found unconscious on the tanktop of the starboard cargo hold access shaft.

Before entering the enclosed space, the duty able bodied seaman (AB) was reported absent from the gangway area by his reliever.

The duty AB was eventually taken out of the confined space.

Attempts by fellow crew members and the paramedics to revive him were unsuccessful and the crew member was declared dead by the shore medical services.

The autopsy did not determine the cause of death although in all probability, the crew member was overcome by lack of oxygen.

As a result of this investigation, two safety recommendations were issued to the vessel's safety managers.

MV Karoline

FACTUAL INFORMATION

Vessel description, crew and external environment

Karoline, a 4,073 GT general cargo, was built by Brodogradiliste 3.Maj Dry Docks, Croatia in 2001 and registered in Malta. She is owned by Cargo Invest Co. Ltd., managed by Technical & Brokerage Services S.r.l., Italy and classed with Registro Italiano Navale. *Karoline* has an overall length of 104.40 m and a beam of 16.20 m. The vessel has a single cargo hold with a capacity of 7,220 m^3.

Karoline operated on international trade. At the time of the accident, she had a crew of 10. The master was Egyptian. The rest of the crew members were Romanian except for the second mate, and the chief and second engineers who were Filipino. English was the working language on board.

The AB involved in the accident was 42 years old. He was first employed at sea in 2003 as an ordinary seaman (OS). Since then, he worked on ro-ro passenger ships, supply vessels, general cargo ships, and cement carriers. He was first employed as an AB in 2007. The AB joined the vessel on 07 June 2011 at Licata, Italy. He was assigned the 0000-0400 and 1200-1600 lookout duties in the watch.

On 19 August 2011, the vessel completed the cargo loading operations at Rijeka and sailed for Turkey with 4,880 metric tonnes of shredded steel scrap. Her mean draft, which was determined by a draft survey, was 6.03 m. The passage to the discharge port was uneventful with *Karoline* tendering her Notice of Readiness to Aliaga Port authorities on 23 August at about 0700. The vessel came alongside at 0925. Discharge operations started soon after all formalities were concluded at about 1310.

At the time of the accident, weather conditions were clear with calm seas inside the port. Outside air temperature was 28°C.

Narrative[1]

On 23 August 2011, the AB was on duty at the vessel's gangway. At 1300, port State Control (PSC) inspectors boarded the ship for an inspection, which lasted just over two hours. At about 1330, the AB asked an OS to relieve him from the gangway watch. At this time, the AB neither specified the reason nor how long he expected to be absent.

At approximately 1345, the OS saw the AB walking close to the port side passageway near the gangway. 30 minutes later, he was again observed on port side aft of the cargo hold close to the workshop, holding a flashlight. The OS reminded him that PSC officers were on board[2].

After about an hour, the OS decided to leave the gangway watch and look for the AB in his cabin. The AB did not answer the door and the OS returned to the gangway. However, 20 minutes later, the OS returned to the AB's cabin but again there was no reply. He proceeded to the galley and asked the cook and a motorman whether they had seen the AB. No one was aware of his whereabouts.

By now, the OS was wondering why the AB had not returned to the gangway; he could see no reason for the latter to miss his gangway watch. At about 1525, the OS reported to the 1600-2000 AB that he had been replacing the missing AB for almost two hours and could not find him anywhere. The AB started to look for his missing colleague. Subsequently, not seeing

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[1] The information in the narrative part of this safety investigation report is extracted from the evidence collected from the crew members and the ISM managers. MSIU was informed of this accident by the managers on 26 August 2011, *i.e.* three days after it happened. Moreover, due to the trading patterns of the ship, MSIU was unable to visit the ship until 03 September 2011.
In this respect, a degree of (human) evidence contamination is considered to have occurred. Moreover, MSIU was unable to collect certain physical evidence, including atmosphere samples from inside the starboard access shaft where the accident happened.

[2] It was claimed that this had to be the last time the OS saw the AB before he was found unconscious inside the starboard access shaft to the cargo hold.

him around, he asked another AB to join him in his search.

It was stated that at about 1525, the first AB was looking on the main deck and observed that the starboard access shaft cover to the cargo hold was open (Figure 1). He thought that this was somewhat peculiar given that this particular access was not normally used by the crew.

Figure 1: Starboard cargo hold access shaft from the main deck

The AB recalled that as he approached the access shaft, he noticed from the main deck that the missing crew member was lying motionless on his left side, on the tanktop of the starboard access shaft to the cargo hold. The AB requested an OS to immediately call the master and inform the other crew members of the situation. He also asked him to bring a flashlight. It was approximately 1535.

The master stated that upon being notified of the matter, he made his way to the main deck, requesting the OS to prepare the breathing apparatus and to organise himself to enter the access shaft in order to check the AB's condition. Evident that medical assistance was required, the master notified the agents to call an ambulance.

In the meantime, the AB attempted to reach his colleague through the same access and down the ladder (Figure 2).

Figure 2: Starboard cargo hold access ladder from the main deck

The AB stated that after going down four or five rungs, he could go down no further due to the intense odour of gas, which irritated his nasal mucosa. He therefore returned to the main deck, brought a BA set from the accommodation, and went down again inside the cargo hold access shaft.

Upon reaching the crew member at the bottom of the access shaft (Figure 3), the AB noticed that his colleague was unconscious with his left foot resting on the lower rung.

Figure 3: Bottom-up view of the starboard cargo hold access from the main deck

The master claimed that he lowered a safety harness to the AB; however, it proved impossible to use because of the space restrictions. A rope was eventually used to pull out the crew member. Attempts to resuscitate

him were unsuccessful, even after the intervention of the shore medical assistance, which arrived on board soon after the ship raised the alert.

Autopsy and toxicological results

The autopsy confirmed that there were no internal and / or external injuries. This indicated that the crew member did not actually fall from a height and therefore he must have been overcome by the atmosphere inside the access shaft once he had reached the bottom.

Following interventions by the Marine Accident Investigation Commission of Turkey, MSIU was informed that several toxicological tests were carried out in order to identify the poisonous gas, if any. Notwithstanding these tests, the results were inconclusive. Therefore, it could not be determined with certainty whether the cause of death was asphyxia due to lack of oxygen or exposure to some poisonous gas. The former possibility, however, seemed to be a more likely cause as discussed below.

The autopsy report mentioned "that the covers allowing the air passage between the enclosed space where the person was and the scrap cargo were open.…" However, following further clarification, it was established that the autopsy report was not referring to the access hole at the very bottom of the access hatch (tanktop level) but to the access to the shaft from the main deck[3].

[3] The ship managers were also approached on this matter in order to provide more information on this matter. The managers reiterated that the access to the cargo hold from the access shaft was blocked by a steel plate and sealed with expanding foam long before the accident happened.

ANALYSIS

Aim

The purpose of a marine safety investigation is to determine the circumstances and contributory causes of the accident as a basis for making recommendations, to prevent further marine casualties or incidents from occurring in the future.

Access to the cargo hold

The death of the crew member occurred inside the starboard access shaft to the vessel's cargo hold, situated at the starboard passageway, several metres forward of amidships. At the bottom of the access shaft was an access hole (Figures 4 and 5), which was found sealed when the MSIU investigators were on board (*vide* Footnote 3).

Figure 4: Ladder leading down the space. The access hole leading to the cargo hold is on the right-hand side

In total, there were four access shafts to the cargo holds – two located forward of the cargo hold, two on the aft side of the cargo hold and two atwartships. The master stated that the access from the port and starboard access was prohibited by the company.

Figure 5: Access hole leading to the cargo hold sealed with expanding foam

In fact, both had been hermetically sealed with expanding foam and this was known to all crew members. Interviewed crew members confirmed that they had not received any specific instructions on being prohibited from using the port and starboard access hatches. However, they were all aware of the potential dangers related to accessing enclosed and confined spaces.

Managers explained that *Karoline* was normally chartered as a cement carrier in bulk. Therefore, due to the nature of cargo, there was little need for the crew to access the cargo hold during loading and / or discharging. Thus, in order to limit the number of access points to the cargo hold, only the fore and aft entry points were designated as cargo hold access points. A decision was therefore taken to seal the port and starboard access shafts from the main deck.

The access cover to the shaft from the main deck (Figure 1) had a three-dog closing arrangement, which secured the cover against rubber packing. This created a weather tight seal. Two of the dog handles could be locked by padlocks. The cover also had padlock eyes welded on the side.

It transpired that no padlock was used to secure the cover. Moreover, there were no warning signs posted prior to the entry of the starboard access trunk to indicate that either entry was prohibited or to be carried out only after an enclosed space entry permit was issued[4] (Figure 6).

Figure 6: "Restricted Area / Zone" signs not painted on the access cover

In fact, the precautionary warnings were painted on the access shaft covers after the fatal accident.

However, notwithstanding the missing padlock/s, it was evident that the access from the main deck was sealed with expanding foam (Figure 7).

Figure 7: (Cured) expanding foam

Nature of cargo and related hazards

Unlikely as it may be, the possibility of poisonous gas inside the space was also analysed.

The loaded cargo was declared as shredded steel scrap. The International Maritime Solid Bulk Cargoes Code lists scrap metal as a cargo without any special hazard. It is also cautioned that the cargo should be kept as dry as

[4] Several crew members indicated that prohibited entrance was implicit rather than explicit.

practicably possible before and during loading, and during the sea passage.

There were no indications that the cargo was wet[5]; the cargo operation took place in August in ambient temperatures exceeding 30°C. The nature of poisonous gases inside the access shaft, if any, had not been identified. It is true, however, that scarp metal may have toxicological hazards especially if trace metals were mixed with scrap.

Moreover, other chemicals may have also released harmful gases[6].

There was, however, one caveat. Whilst the scrap metal may have released toxic gases, the cargo was inside the hold, whereas the fatal accident happened inside the starboard access shaft to the cargo hold.

The reason for the dangerous atmosphere condition inside the shaft remained speculative. An inspection of the access shaft revealed that there were four openings, which could have potentially allowed air / gas to flow in or out of the shaft:

a) the main access opening from the main deck;
b) a manhole in way of starboard side at mid-height inside the shaft, which leads to the adjacent ballast tank;
c) an access hole in way of port side at tanktop level; and
d) a small opening (for the cargo hold's fire extinguishing system pipe) in way of the forward cofferdam bullhead.

Whilst the main deck was not considered to pose any hazards, the manhole mentioned in (b) seemed tight and hermetically sealed. The small opening (d) was examined visually and by hand and it also appeared completely blocked.

The access hole referred to in (c) was found blocked with a steel plate (Figure 5), kept in place by welded steel plates, although not hermetically tight since expanding foam had to be applied all around. The foam was not uniform and its water tightness (or lack of it) could not be ascertained. If not tight, it would have been a plausible path for gas / air exchange from one space to another.

There was no evidence to indicate as to when the access hatch was sealed from the cargo hold. Although the foam looked new, the date when it was applied could not be established[7].

Condition inside the access shaft after the accident

Eight months into the safety investigation, the Turkish Marine Accident Investigation Commission was able to provide MSIU with several photos of the access shaft where the accident happened. The photo (Figure 8) was taken by the Turkish Prosecution Authorities on the day of the accident[8].

Initially, the Turkish authorities were unable to enter the access shaft, due to what has been described as a "terrible smell of gas". They also requested for oxygen measurements for the access shaft but none were available[9]. It was only after the space was ventilated that the local authorities could enter the access shaft, wearing the necessary personal protection aids.

[5] The cargo was loaded in Rijeka, Croatia.

[6] Whilst damp conditions may accelerate oxidation of the cargo (in the presence of oxygen), it was also possible for dry cargo to oxidise, especially if contaminated with other substances / chemicals such as cutting oils, oily rags, or combustible matter, creating pockets of oxygen deficient atmosphere.

[7] Expanding foam hardens after several hours from its application. In the presence of ultraviolet light, it also ages, turns orange in colour, and becomes weaker. Thus, its 'healthy' appearance (albeit very clean), was in no way considered to be an indication of a recent application especially since it was not exposed to direct sunlight.

[8] The Turkish authorities confirmed that they were on board the ship immediately after they received the accident notification, *i.e.* within two hours from the accident.

[9] An oxygen meter was available on board. However, the oxygen levels inside the space were measured by a specialised private company.

Figure 8: Condition of the access shaft several hours after the accident

Figure 8 is a photograph which was taken on the day of the accident from inside the access shaft. The local authorities found a safety harness inside, which was presumably intended to be used after the accident. A blue safety helmet, also found inside the access shaft, was believed to belong to the AB.

Figure 9: Steel plate and expanding foam blocking the access to the cargo hold

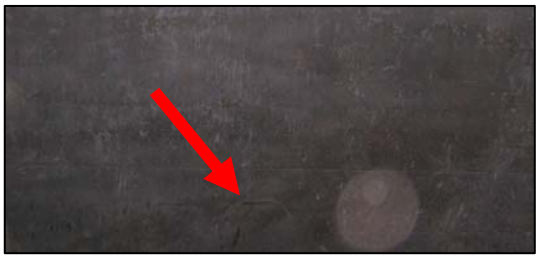

Figure 10: Steel plate from the inside of the cargo hold

The photographs represented as figures 9 and 10 also show that the steel plate between the access shaft and the cargo hold was in place. This increased the probability that the accident happened in an oxygen-depleted space.

Eventually, when MSIU was on board, the access shaft was ventilated for a second time for about four hours. A measurement of the oxygen level at about mid-height inside the access shaft read between 19% and 20% oxygen concentration[10].

The atmosphere was not measured prior to the ventilation in preparation for the safety investigators' entry and therefore there was no indication of the oxygen concentration prior to the ventilation. However, both the master and the AB stated that the overall atmosphere was very stuffy when the shaft was opened.

It is of particular interest that during the rescue attempt, the AB was unable to proceed down the access shaft due to (what he described as) a strong odour of gas. This did not seem to have been the case for the deceased crew member, who managed to go down the entire depth of the access shaft[11].

Considering that there were no samples taken that could give an indication of the gaseous constituents inside the access shaft, it could not be determined how the (first) AB remained unaffected by the strong odour whilst going down the ladder.

The decision to enter the access shaft – initial hypothesis

Although it was only after the accident that the cover to the access shaft was marked to prevent entry, it was claimed that there was a common (implicit) understanding on board that the space was hazardous and entry prohibited. The access shaft may be classified as an enclosed space and as such, enclosed spaces should only be entered under supervision, after the necessary precautions have been taken, and relevant permits issued.

[10] This measurement was taken days after the accident.

[11] As already mentioned, no external injuries were found; this was indicative that the crew member did not fall from a height.

In order to gain access to the shaft, the crew member had to pull open the access hatch cover and in so doing damaging the seal created by the expanding foam. Reflecting on the decision taken to enter the enclosed space, the crew member, even by virtue of destroying the foam, was conscious of the fact that he was crossing a safety boundary – irrespective of the rationale behind his very same decision.

As yet, the risk was accepted and the entry made. Safety studies have shown that if someone estimates that the probability of being injured or endangering his life was sufficiently low, then it was very likely that the risk is taken and the safety warning ignored – irrespective of how clear the message would have been. It was considered that the violation of safety norms was the combination of attitudes (towards risk), the prevailing situation on board, and knowledge on the real risk.

Hence, whilst the entrance into the access shaft was intentional, it could also very well be that the exposure to a hazardous atmosphere was unintentional; a situation which is considered to be extremely dangerous as precautions would not have been adopted prior to exposing oneself to risk.

It remained, however, that gaining access to the shaft for no readily apparent reason related to the operations of the vessel led the question as to the actual reason behind the entry into the space at a time when most probably, PSC officers were on board[12].

Initially, the MSIU's safety investigation was unable to provide an answer. The statements submitted by the crew members neither revealed why the AB had entered the access shaft nor that any one was aware of his intentions and actions.

It therefore seemed that the entry was a pure personal decision for an unknown reason.

Both MSIU and the Turkish Marine Accident Investigation Commission remained open for any new key evidence on this aspect. Whilst MSIU queried several times with the managers on whether there were any developments, the Turkish Marine Accident Commission focused on the visit which the local authorities made soon after the accident.

The decision to enter the access shaft – new evidence

Months after the accident, MSIU and the Turkish Marine Accident Investigation Commission were informed of one possible reason for the AB to enter the access shaft.

The Turkish Marine Accident Investigation Commission learned that the AB and another crew member were collecting fire extinguishers for shore servicing. The authorities also became aware that just before the accident happened, there was a vehicle from a local portable fire extinguisher service company on the jetty near the ship.

Whilst the vessel's fire plan indicated that one portable fire extinguisher was located in the access shaft (Figure 11), several photos of the access shaft indicated a strap to secure a portable fire extinguisher (Figure 12).

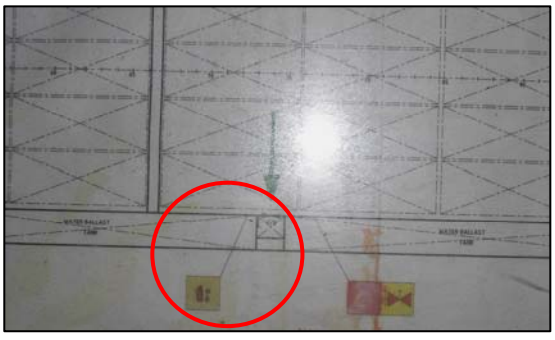

Figure 11: Part of the vessel's fire plan showing the portable fire extinguisher located in the access shaft

[12] MSIU was unable to establish the exact entry time.

Figure 12: Portable fire extinguisher strap located in the access shaft where the accident happened

No portable fire extinguishers were found in the access shaft when the safety investigators boarded the ships days after the accident. In this respect, it cannot be confirmed whether or not the fire plan was accurate at the time of the accident.

It can be stated, however, that if the crew members were indeed inspecting portable fire extinguishers, their activity was not related to the PSC inspection. The Merchant Shipping Directorate within Transport Malta provided MSIU with a copy of the PSC inspection report. On the day, only two deficiencies were identified, relating to the MF/HF radio installation and a missing endorsement application for the chief mate.

Failed safety barriers

Unauthorised entry into enclosed spaces can only be achieved if multiple preventive safety barriers fail[13]. Given that these barriers were surpassed, there was little which could have been done to minimise the hazards within the space. This accident was no exception to this theory.

An analysis of the safety barriers installed on *Karoline* confirmed that the second most reliable safety barrier (the functional barrier) was missing. The space was not locked in order to prevent unauthorised entry. The closed access cover on the deck *per se* was a physical barrier but in its unlocked state, it was easily bypassed, albeit intentionally.

In actual fact, the evidence collected suggested a special emphasis by the company and the crew members at management level on immaterial barriers *i.e.* rules, training, norms, and awareness. As much as being important, immaterial barriers are the weakest of the three types of barriers and are highly dependent on the crew member himself, and his perception of the situation[14].

That perception may have not represented the actual prevailing situation and therefore the effectiveness of immaterial barriers would have been compromised even further. In other words, the entry into the cargo hold access shaft may have been decided on subjective factors.

It was to be expected that the intention of the crew member was to access the shaft (for whatever reason) and come out again. Studies have shown that the crossing of safety barriers is goal driven. Thus, the fact that his safe exit did not materialise, remained a clear indication of an inaccurate assessment of the situation, the benefit of entering the space *vs.* the potential deficit, and inaccurate perception of the risk involved.

The rescue attempt

It was stated that once the AB found his colleague on the tanktop inside the access shaft, he attempted to enter the space without the necessary protective equipment. *A prima facia*, this may be also attributed to a violation of established norms. However, it would be more accurate to attribute this action to an emotional reaction to the situation, which may have also

[13] Irrespective of whether the entry was the AB's personal decision or to collect a portable fire extinguisher, established norms to enter enclosed spaces were not followed. The access is therefore considered to be unauthorised.

[14] This is so even if one had to consider that the AB (irrespective of whatever reason), still decided to enter the access shaft.

deviated the AB from conducting an accurate cognitive assessment of the situation.

Research into this matter suggests that emotional reactions are predominant and therefore capable of driving behaviour.

CONCLUSIONS

1. The nature of gases inside the access shaft has not been identified although it is hypothesised that there was an oxygen deficient atmosphere;
2. The decision by the AB to enter the access shaft was a conscious crossing of a safety boundary, influenced by the attitude towards risk, the prevailing situation and knowledge of the real risk inside the shaft;
3. The investigation could not establish the reason for the entry of the AB inside the access shaft. There is a probability, however, that the AB entered the access shaft to collect a portable fire extinguisher;
4. The second most reliable safety barrier to prevent entry in the access shaft (the padlock) was missing;
5. It was assumed that there was a natural awareness amongst all crew members and that norms and rules on entry into enclosed spaces would be adhered to;
6. The action of the other crew member to enter the access shaft and assist the AB without safety gear was attributed to an emotional reaction to the situation.

SAFETY ACTIONS TAKEN DURING THE COURSE OF THE SAFETY INVESTIGATION[15]

Following the accident, company's procedures have been amended in order to provide more details on the precautions on entering dangerous and confined spaces. The duties and responsibilities of competent and responsible persons with respect to the assessment of an enclosed space have been refined.

A letter to notify these changes has been issued to all vessels under the management of Technical & Brokerage Services S.r.l. In addition to the warning painted on the access covers, the latter have been locked with padlocks. The keys are kept in the master's cabin.

RECOMMENDATIONS

Technical & Brokerage Services S.r.l., Italy is recommended to:

10/2012_01 ensure that all enclosed and confined spaces on board company managed ships are clearly identified, marked as such and kept secure at all times.

10/2012_02 highlight on a regular basis the dangers of entering confined spaces and the importance of following established industry norms in this respect.

[15] **Safety actions and recommendations should not create a presumption of blame and/or liability.**

SHIP PARTICULARS

Vessel Name:	*Karoline*
Flag:	Malta
Classification Society:	Registro Italiano Navale
IMO Number:	9019200
Type:	General Cargo
Registered Owner:	Cargo Invest Co Ltd.
Managers:	Technical & Brokerage Services S.r.l.
Construction:	Steel
Length Overall:	104.40 metres
Registered Length:	96.56 metres
Gross Tonnage:	4073
Minimum Safe Manning:	10
Authorised Cargo:	Solid cargo

VOYAGE PARTICULARS

Port of Departure:	Rijeka
Port of Arrival:	Aliaga, Turkey
Type of Voyage:	International
Cargo Information:	Shredded scrap metal
Manning:	10

MARINE OCCURRENCE INFORMATION

Date and Time:	23 August 2011 at 1525 (LT)
Classification of Occurrence:	Very Serious Marine Casualty
Location of occurrence:	Port of Aliaga
Place on board	Cargo hold starboard access shaft
Injuries / fatalities:	One fatality
Damage/environmental impact:	None
Ship Operation:	Discharging at berth
Voyage Segment:	Arrival
External & internal environment	Clear weather and calm seas. Outside air temperature was 28°C.
Persons on board:	10