Marine Safety Investigation Unit

Transport Malta

SAFETY INVESTIGATION REPORT

201810/032 REPORT NO.: 19/2019 October 2019

MV *BALGARKA*
Crew members' fatality and serious injuries during repairs in a shipyard
28 October 2018

SUMMARY

At about 0900 on 28 October 2018, a crew member sustained fatal injuries and another was admitted to hospital with serious injuries, following a fire on board the Maltese registered bulk carrier MV *Balgarka*, during repairs in dry-dock.

At the time of the accident, both crew members were inside the forepeak tank and hot work was being carried out on the lower platform. Shortly after resuming work, a fire erupted inside the space. One of the fitters managed to escape from the space, albeit with serious burn injuries. The second crew member on the lower platform was unable to escape and was later found at the bottom of the space.

The safety investigation considered two scenarios of fire ignition; either oxygen coming in direct contact with oil and grease, or oxygen enrichment inside the forepeak tank on the face plates of the forepeak bottom girders (platform no. 5).

Considering the safety actions taken by the Company, no recommendations have been made.

MV *Balgarka*

FACTUAL INFORMATION

Vessel

Balgarka was a 25,065 gt, geared bulk carrier built in 2004 in Bulgaria. She was owned by Dolly Maritime Ltd. and managed by Navigation Maritime Bulgare (Navibulgar). *Balgarka* had a length overall of 186.45 m and a moulded breadth of 30.0 m and a summer deadweight of 41,333 tonnes.

The vessel was also fitted with five cargo holds. Pairs of topside and double bottom ballast tanks, corresponding to the cargo holds ran along the entire length of the cargo space.

Propulsive power was provided by a 6-cylinder B&W 6L60MC, slow speed direct drive diesel engine, producing 8,340 kW at 120 rpm. This drove a single, four-bladed propeller to reach a service speed of about 11.5 knots.

Forepeak tank

The forepeak tank, located forward of cargo hold no. 1, extended throughout the entire height, from the main deck to the bottom shell plating. In order to provide structural strength (and facilitate access), four horizontal platforms were fitted, thereby splitting the height of the forepeak into five levels (Figure 1). Vertical ladders fitted between platforms and the bottom of the tank, provided means of access to all five levels.

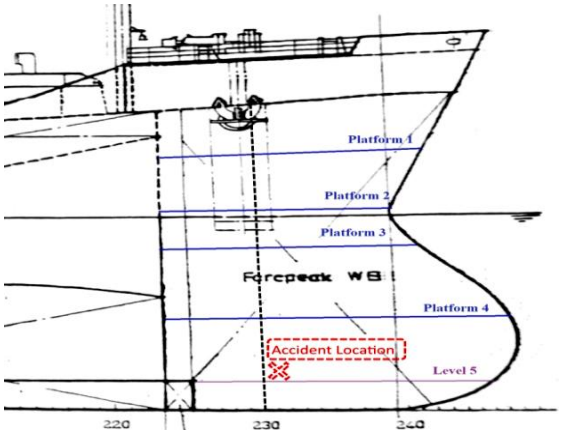

Figure 1: Forepeak tank configuration

While platform nos. 1 to 4 were fully configured platforms with access and drain openings (Figure 2), the bottom most platform no. 5 (where the accident happened) was structured differently, with deep longitudinal girders and face plates of the bottom longitudinal stringer (Figure 3).

Figure 2: Configured platform nos. 1 to 4

Figure 3: Platform no. 5 with deep wells

The depth of the bottom longitudinal girders was about 1.9 m, and the face plates were about 0.25 m wide, providing just enough stepping space.

Above the forepeak tank were the paint store, electrical panels' room, hydraulic room serving windlasses, carpenter space and the deck and bosun's stores. The forepeak ballast line valve was located inside the tank at bottom level. The valve actuator was located inside forecastle, with the valve

spindle passing the whole height of the tank, split in sections by cardan joints and supported at several locations through the platforms. The valve spindle (Figure 4) was located about 1.5 m from the access ladder.

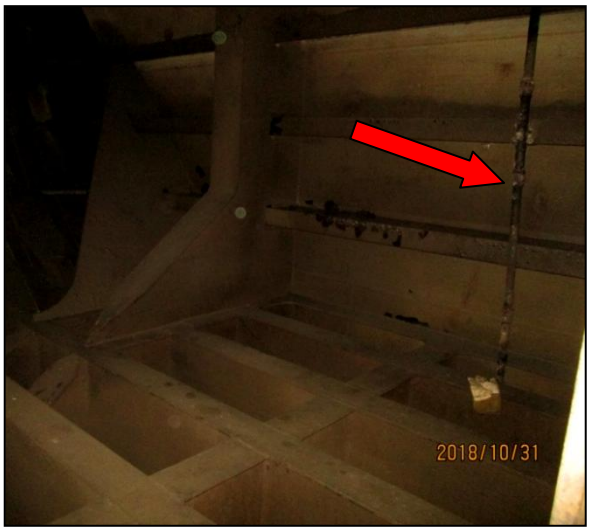

Figure 4: Valve spindle inside the forepeak tank

There was neither fuel nor other liquid spaces surrounding the forepeak. Moreover, only ballast lines were passing inside the forepeak tank.

Crew members

The Minimum Safe Manning Certificate, issued by the flag State Administration on 11 December 2013, required the vessel to be manned by at least six officers and eight ratings, (six deck ratings and two engine-room ratings).

At the time of the accident, *Balgarka* was manned by 27 crew members. All the crew members were Bulgarians, except for a Ukrainian motorman. All officers were in possession of the required national Certificates of Competence as well as the necessary endorsements.

The working language on board was Bulgarian.

The fatally injured crew member was 51 years old, had seven years experience at sea as a fitter and six years and two months employed with the Company. The fitter joined *Balgarka* on 28 September 2018 at Istanbul anchorage.

The medical fitness certificate of the fitter dated 14 September 2018 indicated that he was fit to serve at sea.

The injured crew member, who was 57 years old, had been at sea for 14 years, serving as a motorman for 11 years. He had been employed by the Company for three years as a fitter, working both on deck and in the engine-room.

Weather conditions

The weather was fine with light breeze, without precipitations. Air temperature was 20 °C.

Narrative

Balgarka discharged her cargo of steel slabs at Monfalcone, Italy and returned to Varna, Bulgaria on 17 October. Subsequently, on the next day, she entered Bulyard Shipyard and dry docked for scheduled repairs.

Over the final voyage, whilst transiting the Bosporus, three fitters joined the vessel to assist in the repairs. At the Yard, repair works by the shipyard personnel were carried out concurrently with maintenance performed by vessel's crew. Three fitters were assigned to work on deck. Toolbox meetings were held regularly among repair managers, yard workers and the crew members.

On 27 October, two of the fitters were instructed to proceed with maintenance / repairs on one of the ballast tank's remotely operated valve shaft bearings and joints/cardans. Records and interviews showed that after the ship management carried out their toolbox meeting for some 10 minutes at the master's office, the chief officer assigned the job to maintain the ballast valve shaft inside top side ballast tank no. 4 starboard side, to fitters 2 and 3.

The checklist "Permission for Entry in Confined Space", dated 27 October, specified that all relevant requirements had been fulfilled, along with triple measurement of atmosphere, allowing entry and hot works for three fitters between 0800 and 1700.

Following the toolbox meeting after the lunch break, fitter 1 joined his colleagues and together, they proceeded to the forepeak tank. Subsequently, illumination by means of portable lights and ventilation by compressed air from the shipyard's fixed compressed air distribution system were arranged in the forepeak tank prior to entry. Acetylene and oxygen bottles (complete with reduction valves) were brought and positioned in front of the access leading to bosun's store on the forecastle. The hose and cutter were led down to the forepeak tank.

While the electrician proceeded with arranging portable lights inside the forepeak tank, the fitters commenced maintenance on the ballast valve shaft bearing and supports at the upper platform, working down to the second, third and fourth platforms. Fitter 1 was assigned to work with the acetylene cutter *i.e.*, heating the shaft elements. Fitter 2 was assisting fitter 1, using the wrench to operate the valve shafts. Fitter 3 was observing the work from the uppermost platform (no. 1).

The acetylene gas torch was used to heat bearings, supports and cardans of the ballast valve shaft. Additionally, scrapers, two WD-40 lubricant sprays, wrenches and other oil applicators were used to free the stacked shaft of the valve.

By 1700, on 27 October, all the supports and bearings fitted on the first four platforms had been completed. All tools were left on platform no. 5, including the acetylene cutter. The three fitters vacated the forepeak tank to report to the master on the repair works done for the day.

On the following day, the three fitters resumed repair works inside the forepeak tank. Records showed that the chief officer had tested the atmosphere and confirmed that entry and hot works inside the forepeak tank was safe. The fitters organized their work, started ventilation by means of shore supplied compressed air, and switched on the illumination by portable lights from vessel store.

Fitter 2 was slightly delayed looking for a large wrench to free the jammed valve shaft. When he reached the lowest platform (no. 5) inside the forepeak, fitter 1 had already started heating with the acetylene torch, while fitter 3 remained at the upper platform.

While fitter 1 started heating the valve shaft with the acetylene torch, fitter 2 was behind him, about 1.5 m away and was not able to see directly the work being carried out. Soon after the commencement of the hot work[1], it was reported that a significant volume of fumes started to be generated, prompting fitter 1 to shout to fitter 2 to run[2].

Soon after, both fitters' clothes were on fire; while fitter 2 managed to reach the ladder and climb up to the upper platform (Figure 5), fitter 1 did not manage and remained trapped inside the bilges of the forepeak tank (Figure 6).

Figure 5: Vertical ladder on platform no. 5

[1] Information obtained from the ship suggests that this was between one and three minutes.

[2] During the course of the safety investigation, the MSIU identified conflicting evidence as to whether or not there were actually fumes generated prior to the fire.

Figure 6: Bilges inside the forepeak tank

Post-accident actions

As soon as the news of the accident reached the bridge, the General Alarm was sounded. Soon after, both the master and the chief officer made their way to the forepeak with their breathing apparatus sets and proceeded down to the fifth platform. There, they found fitter 1 without signs of life, at the bottom between the deep girders of the forepeak tank, at the foot of the vertical ladder leading from platform no. 5 to platform no. 4.

An ambulance arrived on site at about 0920, and took (the seriously injured) fitter 2 to the local hospital, where he was transferred to the intensive care unit. In the meantime, the body of the deceased fitter 1 was recovered to the main deck and examined by forensics at around 1200, where he was formally pronounced dead.

Cause of death

At the time of writing, the MSIU still had no official information on the cause of death. Communication with the Bulgarian Maritime Accident Investigation Unit indicated that investigations by the public prosecutor may take a significant amount of time. Evidence has also been removed by the police investigators.

During the consultation period, however, the Company provided the MSIU with a scanned copy of the autopsy report, which indicated that the cause of death was fourth degree burns.

Reported damages

There were no structural damages reported as a result of the fire inside the forepeak tank. However, smoke damage was visible, especially inside the space bilges. In view of the missing physical evidence, the MSIU was unable to determine whether any of the equipment used by the fitters had been damaged.

ANALYSIS[3]

Aim

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

Cooperation

During the course of this safety investigation, MSIU received all the necessary assistance and cooperation from the Bulgarian Maritime Accident Investigation Unit.

[3] The MSIU had no access to physical evidence. Moreover, taking into consideration the lack of eye witnesses, the analysis (and hypothesis) presented in this section had to be researched and hypothesis on the potential scenarios which could have led to the accident had to be generated, keeping in mind the context as described by the crew members.

In addition, the interview with the injured fitter (2) was carried out months after the accident because his recovery was over a period of several weeks. Then, his recollection of the events had been impaired both by the shock and time, not to mention that he was not facing fitter 1 at the time of the accident. Fitter 2 did recall, however, that the accident occurred shortly after the commencement of the hot work at the lowest platform.

Extent of the fire inside the space

Although the surviving crew member on platform no. 5 inside the space was facing the other way, he was able to recall that at the time of the accident, there was neither an explosion nor a fire had been observed. However, considering the injuries sustained by the two crew members, a fire must have resulted at some point. It was very probable that this was a flash fire. Moreover, it may be confirmed that the damages observed in the space were not conducive of an explosion.

Potential causes of flash fire

The information made available suggested that the acetylene gas torch was being used to heat the bearings, supports and cardans of the ballast valve shaft. The acetylene and oxygen bottles were located in the open area on the main deck aft of the forecastle bosun store access door. Scrapers, wrenches, oil applicators and two cans of WD-40 penetrating oil were also used to free the valve stacked shaft.

The safety investigation was of the opinion that whatever the flammable medium (gas), the accumulated volume (albeit within the flammable range) was not excessive and large enough to cause an explosion. To this effect, an overnight leak before the works were resumed in the morning was considered to be highly improbable.

The potential leak of acetylene from the torch or the rubber tubing was also considered during the course of the safety investigation. As much as acetylene is less dense than air (and therefore the leaking gas would tend to rise to the upper spaces), the acetylene dissolved in acetone during the manufacturing process is heavier than air and would tend to sink into depressions, bilge spaces, *etc*.

While it has to be kept in mind that there was no explosion, a fire of this sort would have been localised and in close proximity of the fatally injured crew member. However, the other crew member, standing several metres away was also affected by the fire which, therefore, was not localised.

The use of penetrating oil

It has already been stated elsewhere in this safety investigation report that penetrating oil was being used in the area. The safety investigation had no information on when the penetrating oil was last used, however, it has been taken into consideration during the course of the safety investigation because of the flammable properties which the propellant has.

The can of the penetrating oil carried a warning that flames and heat had to be avoided if the oil was to be used. The safety investigation did not rule out the possibility of penetrating oil (and propellant) particles suspended in the air which ignited shortly after the hot work was resumed. However, it was acknowledged that the fire was not contained within the close proximity of where the hot work was being carried out, considering the injuries sustained by the crew member working in the area.

Oxygen-enriched spaces

The MSIU had already investigated a similar occurrence, which happened on board another Maltese registered vessel while in dry-docks[4]. In that particular fatal accident, the person had been also using acetylene and oxygen enrichment[5] had not been excluded.

One of the main problems with excess oxygen is the potential increase of a fire. Moreover, oxygen is colourless, odourless

[4] *Vide* Safety Investigation Report No. 04/2012.

[5] Oxygen enrichment is the term used to describe situations where the oxygen level is greater in the space than in the air. Literature on the subject matter indicates that in oxygen-enriched atmospheres, oxygen concentration by volume either exceeds 23.5 % at sea level, or the partial pressure of oxygen in the mixture exceeds 175 mmHg.

and cannot be detected by human senses. Contrary to noxious gases, there is no physiological effect on the human body.

Oxygen is denser than air and therefore any leaked gas would have possibly sunk into the lower spaces, similar to the ones below platform no. 5.

Although the exact source of oxygen could not be identified by the safety investigation, the possibility of a leakage in the oxygen pipe connected to the torch, causing an increase in oxygen concentration inside the space at platform no. 5 was initially not excluded, although the same school of thought would have applied for the possible leakage of acetylene, applies in this instance as well. However, at a very late stage during the safety investigation process, the MSIU was informed that laboratory tests on the gas cutter and the hoses revealed no damages/defects.

Literature identifies a number of other potential situations which may lead to excessive oxygen in an enclosed space:

- Use of oxygen to cool the hot air inside the space;
- Excessive amounts of oxygen used, more than it was necessary in the process, leading to unconsumed oxygen in the space at platform no. 5;
- System contamination with, *inter alia*, greases and oil;
- Presence of cleaning solvents, which are not compatible with an oxygen-enriched atmosphere, leading to a potential fire or explosion; and
- Delays in lighting the torch, after the valves were opened.

Once a fire has started in an oxygen-enriched space, combustible material, such as clothing may burn violently, depending on the percentage of oxygen inside the space. The safety investigation considered the flame from the torch as a potential ignition source.

Ventilation of enclosed spaces

The hazards associated with oxygen-enrichment increase when the space is not well ventilated. Literature recommends that in the absence of natural ventilation, a ventilation unit with a capacity of about six air changes per hour shall be provided.

The safety investigation revealed that during the course of the work being carried out inside the forepeak on the 27th and the 28th of the month, no portable fans (and large diameter plastic hoses) were used to ventilate the forepeak tank.

Information made available to the MSIU indicated that high pressure rubber hoses used for compressed air were used to supply air inside the space.

Safety barrier systems

According to the records available, atmosphere tests were carried out in the forepeak tank on the 27th and the 28th of the month. Triple measurements for H_2S, CO and LEL were carried out in the morning and early afternoon (six sets of readings). 20.9 % of O_2 were also measured.

Measurements were carried out by means of a combined gas meter. The length of the fitted rubber hose was about 3.5 m. This would have therefore necessitated measurements at each and every platform to ensure a representative sample of air inside the forepeak tank.

The safety investigation was unable to determine whether the above procedure had actually been followed and therefore it is not clear whether platform no. 5 measurements had been taken from a higher platform. Nonetheless, in view of the way the (flash) fire happened, the MSIU does not believe that LEL was present at the time of measurement.

The combined gas meter came with alarm setpoints for each of the measured gas. The

set point for O_2 was 19.5 % volume (low) and 23.5 % volume (high)[6]. The measured percentage volume of O_2 therefore fell within this range and that reading *per se* was no reason for concern. It would be expected that if the space had an elevated level of O_2 at the time of testing, and subject that the samples taken where representative of the actual atmosphere inside the forepeak tank, then a 'high' percentage by volume of O_2 would have been detected.

To this effect, the safety investigation did not rule out that any oxygen-enrichment of the space may have happened well after the atmosphere tests had been carried out.

The two crew members inside the space were wearing normal working clothes. Taking into consideration the burns sustained by the two crew members, it may be concluded that the clothing was not flame-resistant; conventional protective clothing alone is not considered to be sufficient to mitigate the dangers of an oxygen fire.

CONCLUSIONS

1. Whilst it cannot be ascertained as to what had started the fire, the safety investigation identified two potential scenarios – oxygen coming in direct contact with oil and grease, or oxygen enrichment inside the forepeak tank, in way of platform no. 5;
2. The flame from the torch was considered as a potential ignition source;
3. The damages observed in the space were not conducive of an explosion;
4. Considering the injuries sustained by the two crew members, a flash fire may have resulted at some point;
5. Whatever the flammable medium (gas), the accumulated volume, albeit within the flammable range, was not excessive and large enough to cause an explosion;
6. No portable fans (and large diameter plastic hoses) were used to ventilate the forepeak tank;
7. Any oxygen-enrichment of the space may have happened well after the atmosphere tests had been carried out;
8. The clothing worn by the crew members was not flame-resistant; conventional protective clothing alone is not considered to be sufficient to mitigate the dangers of an oxygen fire.

SAFETY ACTIONS TAKEN DURING THE COURSE OF THE SAFETY INVESTIGATION[7]

During the course of the safety investigation, the Company took the following safety actions:

- Soon after the accident, ventilation inside the forepeak tank was provided by means of a portable ventilator, fitted with a flexible hose;
- Distributed a Safety Circular (149/Dec 2018) within the fleet, highlighting fire prevention , hot work permits, use of flammable aerosols and availability of fire detection and fire fighting equipment;
- Significant amendments to the 'hot work permit' procedure have been carried out;
- A fresh risk assessment is specified in the new version of the checklist, prior to the commencement of hot work;

[6] This is subject that the setpoints had not been changed on board.

[7] **Safety actions shall not create a presumption of blame and / or liability.**

- Levels of O_2, H_2S, CO, LEL, and CH_4 shall be measured and recorded;
- The accident was discussed during the shore-held ISM seminars;
- Pre-boarding briefs with crew members include discussion of the accident;
- Crew members received further training in advanced fire-fighting;
- All crew members proficiency in fire safety is upgraded in the Company's training centre. The training is tailored for the crew members' needs.

RECOMMENDATIONS

Taking into consideration the safety actions taken by the Company, no recommendations have been made.

SHIP PARTICULARS

Vessel Name:	*Balgarka*
Flag:	Valletta
Classification Society:	Lloyd's Register of Shipping
IMO Number:	9158159
Type:	Bulk carrier
Registered Owner:	Dolly Maritime Ltd.
Managers:	Navigation Maritime Bulgare (Navibulgar)
Construction:	Steel
Length Overall:	186.45 m
Registered Length:	177.00 m
Gross Tonnage:	25,065
Minimum Safe Manning:	14
Authorised Cargo:	Solid cargo in bulk

VOYAGE PARTICULARS

Port of Departure:	Monfalcone, Italy
Port of Arrival:	Varna, Bulgaria
Type of Voyage:	International
Cargo Information:	In Ballast
Manning:	27

MARINE OCCURRENCE INFORMATION

Date and Time:	28 October 2018 at 0900 (LT)
Classification of Occurrence:	Very Serious Marine Casualty
Location of Occurrence:	Bulyard Shipyard, Varna
Place on Board	Forepeak Tank
Injuries / Fatalities:	One fatality and one serious injury
Damage / Environmental Impact:	Smoke damages inside the forepeak tank
Ship Operation:	Alongisde / Maintenance
Voyage Segment:	Arrival
External & Internal Environment:	The weather was fine with light breeze, without precipitations. Air temperature was 20 °C. Artificial lighting inside the forepeak tank.
Persons on board:	27