MARINE SAFETY INVESTIGATION REPORT

Safety investigation into the fire inside a cargo hold on board the Maltese registered container ship

Barzan

In position 44° 07’ N  009° 12’ W
on 07 September 2015

201509/005
MARINE SAFETY INVESTIGATION REPORT NO. 18/2016
FINAL

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Malta
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Managers of MV Barzan

Master and crew members of MV Barzan

Voyage Data Recorder of MV Barzan

DNV GL survey reports
<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AB</td>
<td>Able Bodied seaman</td>
</tr>
<tr>
<td>AIS</td>
<td>Automatic Identification System</td>
</tr>
<tr>
<td>CH</td>
<td>Cargo hold</td>
</tr>
<tr>
<td>cm</td>
<td>Centimetres</td>
</tr>
<tr>
<td>CO₂</td>
<td>Carbon dioxide</td>
</tr>
<tr>
<td>GT</td>
<td>Gross tonnage</td>
</tr>
<tr>
<td>IMDG</td>
<td>International Maritime Dangerous Goods Code</td>
</tr>
<tr>
<td>ISM</td>
<td>International Safety Management</td>
</tr>
<tr>
<td>kW</td>
<td>Kilowatt</td>
</tr>
<tr>
<td>LOA</td>
<td>Length overall</td>
</tr>
<tr>
<td>LT</td>
<td>Local time</td>
</tr>
<tr>
<td>Lts</td>
<td>Litres</td>
</tr>
<tr>
<td>m</td>
<td>Metres</td>
</tr>
<tr>
<td>m²</td>
<td>Metres squared</td>
</tr>
<tr>
<td>Min</td>
<td>minute</td>
</tr>
<tr>
<td>MRCC</td>
<td>Marine Rescue Coordination Centre</td>
</tr>
<tr>
<td>MSIU</td>
<td>Marine Safety Investigation Unit</td>
</tr>
<tr>
<td>nm</td>
<td>Nautical miles</td>
</tr>
<tr>
<td>NT</td>
<td>Net tonnage</td>
</tr>
<tr>
<td>OOW</td>
<td>Navigational officer of the watch</td>
</tr>
<tr>
<td>PAN PAN</td>
<td>An urgency call which is used when a distress call cannot be justified but there is an urgent message to transmit concerning the safety of the vessel or the safety of a person</td>
</tr>
<tr>
<td>RPM</td>
<td>Revolutions per minute</td>
</tr>
<tr>
<td>STCW</td>
<td>International Convention on Standards of training, Certification and Watchkeeping for Seafarers, 1978, as amended</td>
</tr>
<tr>
<td>TEU</td>
<td>Twenty-foot equivalent unit - a measure used to describe the capacity of container ships</td>
</tr>
<tr>
<td>UASC</td>
<td>United Arab Shipping Company</td>
</tr>
<tr>
<td>UTC</td>
<td>Universal Time Coordinated</td>
</tr>
<tr>
<td>UMS</td>
<td>Unmanned Machinery Space</td>
</tr>
<tr>
<td>VDR</td>
<td>Voyage data recorder</td>
</tr>
<tr>
<td>VHF</td>
<td>Very high frequency</td>
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SUMMARY

At about 2209 (local time) on 07 September 2015, a fire was detected inside one of the cargo holds of Barzan, a Maltese registered container ship. At the time, the vessel was about 60 nautical miles off Cabo Finisterre.

The crew responded and commenced fire-fighting with boundary cooling and the use of the water drenching system on board. Subsequently, the fixed CO₂ system was used but due to a number of leaks in the CO₂ line, the required amount of gas did not reach the cargo hold to be effective to smother the fire. The starboard fire main line then developed a large leak at a joint in the under deck passage way and had to be isolated. This restricted the fire-fighting efforts to only the port side, and rendered the starboard side water drenching system unusable.

Eventually, the crew members, were able to control and restrict the fire and subsequently, the vessel resumed her passage, although was instructed to head to Rotterdam, where she arrived safely on 10 September. The fire was finally extinguished on 14 September by the Port of Rotterdam’s fire brigade.

Barzan sustained minor structural damage in cargo hold no. 2. The CO₂ system had to be inspected and overhauled and the starboard fire main line was adjusted and repaired.

The safety investigation concluded that although the CO₂ system and fire mains had been tested satisfactorily prior to the vessel’s delivery in May 2015, the quality of the workmanship had contributed to the subsequent failure of both systems.

The Marine Safety Investigation Unit has made two recommendations to the flag State Administration and United Arab Shipping Company, the managers of Barzan, aimed at improving fire safety on board.
# FACTUAL INFORMATION

## 1.1 Vessel, Voyage and Marine Casualty Particulars

<table>
<thead>
<tr>
<th>Name</th>
<th>Barzan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flag</td>
<td>Malta</td>
</tr>
<tr>
<td>Classification Society</td>
<td>DNV GL</td>
</tr>
<tr>
<td>IMO Number</td>
<td>9708851</td>
</tr>
<tr>
<td>Type</td>
<td>Container Ship (Fully Cellular)</td>
</tr>
<tr>
<td>Registered Owner</td>
<td>Barzan Ltd.</td>
</tr>
<tr>
<td>Managers</td>
<td>United Arab Shipping Company</td>
</tr>
<tr>
<td>Construction</td>
<td>Steel (Double bottom)</td>
</tr>
<tr>
<td>Length overall</td>
<td>400.0 m</td>
</tr>
<tr>
<td>Registered Length</td>
<td>383.0 m</td>
</tr>
<tr>
<td>Gross Tonnage</td>
<td>195,636</td>
</tr>
<tr>
<td>Minimum Safe Manning</td>
<td>15</td>
</tr>
<tr>
<td>Authorised Cargo</td>
<td>Containers</td>
</tr>
<tr>
<td>Port of Departure</td>
<td>Port Said, Egypt</td>
</tr>
<tr>
<td>Port of Arrival</td>
<td>Rotterdam, The Netherlands</td>
</tr>
<tr>
<td>Type of Voyage</td>
<td>International</td>
</tr>
<tr>
<td>Cargo Information</td>
<td>Containers</td>
</tr>
<tr>
<td>Manning</td>
<td>24</td>
</tr>
<tr>
<td>Date and Time</td>
<td>07 September 2015 at 2209 (LT)</td>
</tr>
<tr>
<td>Type of Marine Casualty</td>
<td>Serious Marine Casualty</td>
</tr>
<tr>
<td>Place on Board</td>
<td>Cargo hold no. 2</td>
</tr>
<tr>
<td>Injuries/Fatalities</td>
<td>None</td>
</tr>
<tr>
<td>Damage/Environmental Impact</td>
<td>Damage to cargo hold structure</td>
</tr>
<tr>
<td>Ship Operation</td>
<td>Normal Service</td>
</tr>
<tr>
<td>Voyage Segment</td>
<td>Transit</td>
</tr>
<tr>
<td>External &amp; Internal Environment</td>
<td>Good visibility. ENE wind, Beaufort 6-7 with moderate seas.</td>
</tr>
<tr>
<td>Persons on Board</td>
<td>24</td>
</tr>
</tbody>
</table>
1.2 Description of Vessel

1.2.1 General
The Maltese registered Barzan (Figure 1) is a fully cellular container ship built in 2015 at the Hyundai Samho Heavy Industries Co. Ltd. Shipyard in South Korea. Barzan was delivered to her owners on 08 May 2015 and at the time, was the largest container vessel in the world, capable of carrying about 18,800 Twenty Equivalent Units (TEU). She has a gross tonnage (gt) of 195,636 and a deadweight of 199,744 tonnes. The vessel is classed by DNV GL. Barzan is owned by Barzan Ltd. and managed and operated by United Arab Shipping Company (UASC), based in Dubai, United Arab Emirates. The Company has 11 ships registered under the Maltese flag.

The vessel has a length overall of 400.0 m and a beam of 58.6 m. Her depth is 30.6 m and her maximum draught, when fully loaded, is 16.0 m. Barzan’s propulsive power is provided by a 2-stroke single acting diesel engine, capable of producing 40,000 kW at 72 rpm. The engine drives a single fixed pitch propeller that gives her a maximum speed of 22 knots\(^1\) and a service speed of 18 knots. The vessel has two tunnel thrusters located forward.

Barzan has 10 cargo holds (CHs). CHs nos. 1 to 4 are located forward of the main superstructure. CHs nos. 5 to 9 are located between the superstructure and the engine casing. The 10\(^{th}\) CH is located aft of the engine casing (Figure 2). The vessel has 75 cargo bays.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure1.jpg}
\caption{MV Barzan}
\end{figure}

\(^1\) One knot is equal to 1.852 km hr\(^{-1}\).
Figure 2: MV Barzan – Profile view of the General Arrangement plan
1.2.2 Cargo hold fire-fighting equipment

*Barzan*'s CHs were protected against fire by a detection system and a fixed CO$_2$ fire-fighting system. In addition, CHs nos. 1, 2, and 3, which were capable of carrying dangerous cargo, were fitted with a water drencher system. *Barzan* was also fitted with two bilge, fire and general service pumps, rated at 650 / 380 m$^3$/hr$^{-1}$ respectively and one emergency pump, rated at 72 m$^3$/hr$^{-1}$ that could supply water for fire-fighting purposes.

The fire detection system was a smoke detection system (Figure 3) that consisted of a smoke detection panel in the CO$_2$ room, a control panel on the bridge, and a fan unit for drawing air from the cargo holds. A network of pipes, the same used for the distribution of CO$_2$, was used to simultaneously draw air samples from all cargo spaces, which were then fed into the smoke detection panel. The system was manufactured by ‘Safetec’.

On board *Barzan*, both the fire extinguishing and the smoke detection systems were connected to the same network of pipes by means of three-way valves. The system continuously monitored all the air samples drawn from the cargo holds. Each detector line was connected to its own built-in detector so that a fire could be identified at its place of origin. The fire detection display panel (Figure 4) was located on the bridge.

![Figure 3: Schematic drawing of the fire detection system](image_url)
The fixed CO₂ fire-fighting system covered all the CHs and the engine-room. The system was fitted with 662 cylinders, each weighing 45 kgs. The system was supplied and fitted by NK Co. Ltd. A schematic diagram of the system and its instruction can be found in Annexes 1 and 2 respectively. The main CO₂ room and its control station were located on the starboard side of the upper deck of the accommodation block (Figure 2).

The water drencher heads were located inside the hatch covers. When required, short hoses would need to be coupled from the fire hydrants to couplings recessed in the hatch covers (Figure 5).
The system was designed to provide about 5 lts min$^{-1}$ m$^{-2}$ of the horizontal area of the cargo space. The starboard hatch covers were supplied by the starboard fire main line and the port hatch covers by the port fire main line. The connecting hoses and couplings diameters were 50 mm and were located in bins adjacent to the hatch covers, readily accessible in case of an emergency.

1.3 Manning and Crew

Barzan was manned by 24 persons, including the master, four navigation watchkeeping officers (OOWs), the chief engineer and three engineers. Most of the officers were Egyptian nationals with the exception of the master, second mate, third engineer and electrician who were Indian, Syrian and Jordanian nationals respectively. The crew ratings were Filipino and the working language on board was English. Barzan was manned in excess of the Minimum Safe Manning Document issued by the flag State Administration.
The watchkeeping hours on the bridge were divided between the three deck officers on a '4-on, 8-off' basis. The chief mate was on ‘day work’ as was the engine-room complement. The engine-room was certified as an unmanned machinery space (UMS) operation and at the time of the accident, it was unmanned.

1.3.1 Master
The master was 56 years old and first went to sea as a cadet in 1976. He obtained his master’s Certificate of Competency in 1984 and was given his first command during the same year. He joined UASC in 1986 and has been sailing in this rank since. He joined Barzan on 16 July 2015.

1.3.2 Chief mate
The chief mate was 47 years old and had initially joined the Egyptian navy. He obtained his master’s Certificate of Competency in 2001. He joined UASC in 2008 and had about 13 years experience as a chief mate. He joined Barzan on 30 June 2015.

1.3.3 Third mate (0800-1200)
The third mate was 29 years old and had about eight years of seagoing experience. He had a chief mate’s Certificate of Competency, which he had obtained in 2014. He had joined UASC in 2009 and was promoted to third mate in 2010. He had signed on the vessel on 08 May 2015, when the vessel was delivered to UASC.

1.3.3 Chief engineer
The chief engineer obtained his Certificate of Competency in 2004 and joined UASC during the same year. He was promoted to rank in 2010 when he was 44 years old. The chief engineer joined the vessel on 07 August 2015.
1.4 Narrative

1.4.1 Background

*Barzan* was operated on the Asia to Europe container service 1 (Figure 6). Her usual route entailed calling at Qingdao, Shanghai, Ningbo, Xiamen, Yantian, in China and Port Kelang Indonesia before crossing the Suez Canal. Thereafter, the vessel would head for Felixstowe, UK; Hamburg, Germany; Rotterdam, The Netherlands and Antwerp, Belgium before heading back East.

![Figure 6: Trading route of Barzan](image)

At the time of the accident, *Barzan* was on voyage number 1432W and had on board 15,587 TEUs that were bound for Northwest Europe. 56 TEUs contained various classes of International Maritime Dangerous Goods (IMDG).

1.4.2 Events leading up to the fire

At about 1600 (LT) on 01 September, *Barzan* cleared the Suez Canal and headed for Felixstowe. On 06 September, the vessel cleared the Strait of Gibraltar and entered the Atlantic Ocean. Until then, the voyage had been uneventful.

At about 2209\(^2\) on 07 September, the fire alarm activated (Figure 4) on the bridge and indicated that there was a possible fire in CH no. 2 aft. The third mate (2000 - 2400), who was the OOW at the time, informed the master and the duty engineer of the alarm. The master instructed the chief mate and the duty AB to go to the area and investigate. Soon

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\(^2\) The clocks on board were initially maintained on UTC +1, and subsequently changed to UTC +2 as the vessel arrived at Rotterdam.
after, the chief mate reported that he could actually see smoke coming from the central hatch covers of CH no. 2 (Figure 7).

![Figure 7: Plan view of CH no. 2](image)

The master sounded the general alarm and also announced the nature of emergency on the public address system. At about 2212, the crew was mustered at the emergency stations. The master requested to have the deck lights switched on, as well as the fire pump and an additional steering gear pump to be started. He also instructed that the CH fans are stopped and ventilation closed.

The chief mate arranged the emergency teams into four squads. He instructed two teams to rig the fire hoses and start boundary cooling and the other two teams to stop ventilation to the CH. He also instructed the team to rig the short connection hoses between the fire mains and water drenching system located in the hatch covers (Figure 5). The chief mate then asked the master to confirm whether it was safe to use seawater and CO₂ in the cargo hold to fight the fire, given that the CH also contained three containers of IMDG cargo (Class 3)³.

At 2225, the master checked the cargo plan and IMDG packing list and confirmed that it was safe to use both media for fire-fighting. The chief mate noted the temperature in the CH using a hand held infrared thermometer (Figure 8). The thermometer read 35 °C. The source of heat was eventually identified in an area located between row 2 and 4 of the aft part of Bay 19.

³ Class 3 – Flammable liquids.
Figure 8: Hand held infrared thermometer

The master then instructed the water drenching system to be opened. At the same time, he reduced speed and adjusted the heading to keep the vessel clear of the traffic that was heading/exiting the nearby traffic separation scheme, off Cabo Finisterre (Figure 9).

Figure 9: Position of *Barzan* when fire alarm activated
The master also issued a PAN PAN message on VHF channel 13 and 16. Thereafter, he stopped the vessel and drifted to keep the wind abaft the beam so as to keep the smoke away from the accommodation.

At 2229, the master contacted the Company to report the situation. At 2230, MRCC Finisterre contacted the vessel to enquire whether any assistance was required. At about the same time, the master noticed that the volume of smoke was increasing, despite the boundary cooling and water drenching into the CH.

At 2321, the master instructed the chief engineer to proceed to the CO₂ room and prepare to release the gas into the CH. At 2324, he instructed the emergency team to stop the water spray, clear the area and muster aft. The chief mate then met the chief engineer and confirmed to him that the CH was full and that all ventilation had been closed. They also confirmed that based on the instructions posted, 231 bottles of CO₂ had to be released into the CH (Figure 10). At 2326, the master instructed the chief engineer to release the CO₂ in CH no. 2. The chief engineer first closed the air sampling line on the fire detection system, opened the control valve cabinet (Figure 11) and opened valves 1 and 2 (full condition).

![Figure 10: Number of CO₂ bottles to be discharged](image)

![Figures 11 and 12: Valve control and pilot bottle for CH no. 2](image)
The chief engineer also opened the cabinet containing the pilot cylinders and opened the valve (Figure 12). Immediately, an amount of gas started to leak between the cylinder and piping. The valve was closed and the connection tightened by an adjustable spanner, which stopped the leak. The chief engineer then re-opened one pilot cylinder and pulled levers 1 and 2 to the open position (Figure 12).

Thereafter, the main CH inlet valves (Figure 13) started to open and the chief engineer could hear the pilot gas progressing to the main cylinders and releasing the main supply of CO₂ gas into the pipeline to the CHs. After about one minute, all the crew members present in the CO₂ room heard a loud bang and saw a dense cloud of CO₂ envelope the compartment. The bosun and the second engineer escaped into the main accommodation and the chief mate, chief engineer and fourth engineer escaped via the main entrance on to the main deck.

![Figure 13: CO₂ distribution manifold and pipeline](image)

The master became concerned when the saw a large cloud of gas coming out of the CO₂ room and instructed the third mate to shut the accommodation ventilation fans so as to prevent any CO₂ from entering the accommodation. The third mate switched off the fans from the emergency stop switch box located on the bridge by pushing the button marked ‘ES-B’ (Figure 14).
In the meantime, the chief mate also instructed the bosun to proceed to the under deck passageway and check whether the CO$_2$ valve to CH no. 2 had opened. The bosun reported back almost immediately that there was a concentration of gas in the under deck passageway. To this effect, he was instructed not to enter but open the other watertight doors at either end of the passageways (to ventilate the area) and then return to the main deck.

Shortly afterwards, at 2328, the vessel suffered a black out and the main engine stopped. The emergency generator started at 2329, supplying the vessel with essential but limited power. At 2331, the main generators were re-started and power was restored. By 2342, the main engine was ready to be re-started and at 2345, the main fire pump was re-started and water spraying into the CHs and boundary cooling was resumed.
At 0000 on 08 September, MRCC (Marine Rescue Coordination Centre) Finisterre was contacted and provided with an update of the situation. At 0005, the vessel suffered another black out when a third generator was being synchronised, causing the main engine to stop. Power was restored after two minutes and the main engine was ready again at 0032. At 0037, MRCC Finisterre advised the master that three helicopters were standing by in case the situation on board deteriorated. At 0045, the quantity of smoke was noticed to be the same and the temperature was recorded to be 40 °C.

At 0100, the DNV GL’s emergency response service was activated and was provided with the necessary information to assess the stability of the vessel. The chief engineer also advised the master that he considered the remaining CO₂ system inoperative / unavailable until a full check of the system was carried out.

At about 0216, a surveillance helicopter deployed by MRCC Finisterre flew around the vessel to assess and report on the situation. At 0230, the second engineer reported water in the starboard under deck passage way and that the water level had almost reached an electrical panel. The power to the panel was isolated and at 0235, the starboard fire main line was also isolated as the water leak was traced back to a leaking expansion joint. At 0248, the quantity of smoke was reported to be the same and the temperatures noted to be 20 °C forward and between 25 °C and 27 °C aft.

At 0300, as advised by the DNV GL emergency response service, the vessel ballasted double bottom tanks nos. 5, 6, and 7 to increase the stability and reduce stresses in the structure.

By 0330, the repairs to the expansion joint of the fire main line remained unsuccessful. The temperature inside Bay 19 was noted to be 35 °C with no changes in other locations. As the starboard side fire main line remained inoperable, the crew rigged additional fire hoses using hydrants on the port side and secured them so as to direct water in between the gaps of the hatch covers (Figures 15 and 16). The crew members were not able to rig hoses from the port side hydrants into the water drenching inlet because the hoses were in short lengths and the main fire hoses were 65 mm, whereas the water drenching supply hydrants, couplings and hoses were all 50 mm.
At 0445, MRCC Finisterre was advised that the fire was under control and that the crew was monitoring the situation. At 0518, the temperature at the aft hatch cover was noted to be between 29 °C and 44 °C. At 0635, a search and rescue vessel (MV Dona Inda) arrived on site and stood by to render the necessary assistance.

Between 0700 and 0715, CH nos. 1 and 3 were checked for smoke ingress and temperature. No smoke was noted and the temperatures were normal between 17 °C and 24 °C. The oxygen level was also noted to be normal. At 0848, the chief mate noted that the temperature at the aft part of the CH had decreased to 29.5 °C and that the smoke intensity was now light. This information was relayed to MRCC Finisterre.

At 0902, the chief mate entered the CH, wearing a breathing apparatus. He could only inspect the top compartment due to dense smoke inside. The temperature was noted to be 26.6 °C. He exited the CH at 0925. At 1015, the supply to the water spray (sprinkler) system was stopped to note the effect. At 1055, however, the smoke was noted to increase and the temperature also started to rise. The water supply to the drencher system

**Figure 15 and 16: Fire hoses rigged and directed in gaps of hatch cover**
was resumed and the contaminated fire-fighting water from CH no. 2 was transferred to double bottom tank no. 9.

At 1130, the Company instructed the master to resume passage but to divert to Rotterdam instead of proceeding to Felixstowe.

1.4.3 Passage from Bay of Biscay to Rotterdam

The vessel resumed her passage and fire-fighting efforts were maintained by the crew. By this time, the crew were split into teams and the boundary cooling and temperature of the CH were constantly monitored. The contaminated water was periodically transferred to various empty double bottom tanks.

*Barzan* arrived off Rotterdam on 10 September and anchored at 0854\(^4\). At 1305, the vessel was instructed to heave up the anchor and head towards a position, about eight nautical miles from the pilot station. At 1408, the anchor was aweigh and the vessel proceeded to pick up the Harbour Master and other port officials so that they could assess the situation and decide on whether it was safe for *Barzan* to enter the port. At 1657, the port officials boarded and disembarked at 2112 after assessing the situation. The Harbour Master agreed to authorise the vessel’s entry in port and at 0000 on 11 September, and a pilot boarded to berth the vessel.

By 0248, the vessel was secured alongside at a berth in Euromax Terminal. At 0554, the discharging operation to remove containers from the hatch covers started. During this period, the crew maintained a fire watch, and water supply into the CH through the drencher system continued. The port fire brigade, which was present since the vessel’s arrival, also continued to monitor the situation.

At 1736 on 12 September, cargo operations were stopped and at 1754, the pilot boarded the vessel and shifted her to RWG Terminal where CH no. 2 hatch covers were to be taken off. The vessel completed mooring operations at 2024. At 1152 on 13 September, the forward hatch covers (Bay 14) were taken off. The containers stowed in that position appeared intact and clean.

\(^4\) UTC +2.
The stevedores then progressed to take off the aft hatch covers (Bay 18/19). As soon as the aft hatch covers were removed, the volume of smoke increased (Figure 17 and 18). The attending fire fighters also spotted the seat of the fire where flames were now visible and started to fight the fire. Fire-fighting efforts continued into the night and at 0315 on 14 September, the fire brigade declared the vessel to be safe.

The fire brigade estimated that a total of 9 containers located in and around Bay 19 had been affected by the fire (Figures 19 and 20).

Figures 17: Smoke from CH no. 2  
Figures 18: Smouldering container  
Figures 19 and 20: Damages in and around seat of fire
1.5 Post fire survey

An occasional survey, carried out by DNV GL, identified the extent of the damage. The damage (Figure 21) in CH no. 2 was restricted to between frames 142 and 143 and rows 4, 6 and 8. It consisted of:

- buckling of structural members in way of row no. 6: stringer deck no. 2, second deck, long web including the stiffeners between rows nos. 4/6;
- between rows nos. 6/8 stringer deck no. 2, upper deck no. 2 and the transversal bulkhead at frame 143 including the horizontal stiffeners were affected;
- the railing at stringer deck no. 2 was missing and others buckled; and
- the electrical cabling and lighting fixtures were found burnt.

An inspection of the CO₂ fire extinguishing system found that 231 bottles of CO₂ had been discharged and that there were a number of leaks in the system. A large leak at the main manifold flange (Figure 13) in the CO₂ room was due to a gasket that had blown out during discharge. A number of flanges located in the under deck passageway were also identified to be leaking and required their gaskets to be changed and joints re-tightened.
The starboard fire main pipe line’s coupling had shifted by over 25 mm and had started leaking (Figure 22) because the ends of main pipeline were noted to be apart further than required and could only be rectified by inserting a new short section (Figure 23).

Figure 22: Leaking main fire line

Figure 23: Modified main fire line coupling
2 ANALYSIS

2.1 Purpose

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

2.2 Cause of the Fire

The MSIU determined that there were 9 IMDG containers loaded in CH no. 2 containing IMDG Class 2.1, 3, 8 and 9\(^5\). However, according to the Bay plan, none of these containers was located near the seat of the fire, which was estimated to have been in the region of 19-06-12 and 19-06-14 (Figure 24). Moreover, when the CH was discharged at Rotterdam, all of these containers were accounted for and were noted to be intact. Therefore, the MSIU concluded that none of the declared IMDG containers had caused or caught fire.

Figure 24 – Profile view of CH no. 2 showing seat of fire

\(^5\) Class 2.1 – Flammable gases, Class 8 – Corrosive substances, Class 9- Miscellaneous dangerous substances.
The safety investigation could not determine the actual cause of the fire as the affected containers had been discharged before the investigation team boarded the vessel. However, it is thought that the containers located in or around the seat of the fire may have contained undeclared IMDG cargo. Figures 20 and 21 show the damage to the ship’s structure, suggesting that there must have been some explosive force, which distorted the railings in the area. This explosive force could only be consistent with dangerous cargo being incorrectly stowed (prior to boarding) and becoming heated to a point where it has exploded, causing the doors to burst outwards and damaging the railings.

The only explanation of not declaring the container as IMDG cargo would have been to avoid paying the freight costs associated with its carriage and its additional paperwork. Such a practice is dangerous and can put the life of the crew, the vessel and the environment at risk.

2.3 Failure of the CO₂ System

Prior to the vessel’s delivery on 08 May 2015, the CO₂ system was inspected and tested by DNV GL and an owner’s representative. The tests were carried out on 10 and 13 April 2015 and consisted of blowing air through the system, testing the manifolds and pilot lines for leakages, weight of CO₂ cylinders and a full function test of the system. These tests were acceptable to both DNV GL and the owner’s representative and therefore in theory, the system should have performed as it was designed to do.

Although the chief engineer operated the system correctly and the system activated the correct number of CO₂ cylinders (231), the system did not fulfil its purpose because of, at least, two known leaks that prevented the CO₂ gas from being delivered to CH no. 2. These leaks, particularly the leak in the CO₂ room, could have been fatal had the crew members not managed to escape the space. The system also failed the very purpose for which it was installed and had it not been for the crew’s efforts in controlling the fire, the lives of the crew and the structural integrity of the vessel would have been at risk.

It is accepted that the leaks in the system were latent and it is the safety investigation’s view that they would probably have remained latent even if an annual and thorough examination of the system were undertaken as required by the vessel’s planned
maintenance system. Nonetheless, this examination would not have been undertaken until some date in May 2016. It was also possible that some of the flange connections became loose as the vessel’s structure flexed during her maiden voyage and these would not have been identified unless a pressure test of the system was carried out.

During the examination of the system by an approved service company, the engineers found some other flange connections in the under deck passage leaking. They discovered that in some areas, two gaskets had been used to seal the flange connection as it was not possible to pull the two flanges together. It was only after they fitted special gaskets and tightened the bolts with a hydraulic torque machine that they achieved a good seal. The service engineers also found that although the main section valve of CH no. 2 had opened when the system had activated, on re-testing the valve, it failed the test because the spindle setting was out by 13 mm. This valve had to be overhauled and adjusted by a specialist company in Rotterdam.

The number of leaks identified by the service engineers, the use of double gaskets to seal some flanges and the incorrect spindle setting of CH no. 2 section valve clearly sheds doubts on the quality of workmanship when the system was initially installed at the shipyard.

2.4 Effectiveness of the Drencher System

As soon as the starboard fire main line was isolated, the vessel lost about 50% of its capability to fight the fire in CH no. 2 (through the loss of the water drenching system). This was because the connecting hoses between the hydrant and the inlet coupling on the hatch covers were short and a conventional fire hose could not be used, given that there was a difference in the size of couplings and hoses (65 mm instead of 50 mm).

The seat of the fire was on the port side of the CH and it was important to keep the starboard containers cooled down especially since three Class 3 IMDG containers were located nearby. Although the crew members were able to spray water in between the gaps in the hatch covers (Figure 15) using fire hoses, this was not as effective as the drenching system would have been, had it been operational. It also created another problem whereby the volume of water into the CH from the fire hoses was significantly larger than if it was passed through the drenching system.
It was fortunate that the seat of the fire was on the port side of the centre line of the CH as the crew members were able to control the fire in this region because of the drenching system. Had the fire been located on the starboard side, the outcome of this emergency could have been different as the crew members would not have been able to restrict the fire by using only fire hoses through the gaps of the hatch covers.

The concept of a drenching system is to create a low volume water spray / curtain to contain and restrict a fire in a section of a large space. Although the difference in the sizes of the hoses and couplings is understandable, *i.e.* to restrict the amount of water entering the CH, it would appear that when the system was designed, it did not take into account any redundancy, in cases where there would be a loss of water supply or fire hydrants when it was most required.

### 2.5 Loss of Power

The vessel suffered a loss of power on two occasions during the fire-fighting efforts. The first occasion was when the accommodation ventilation was shut down. The second power loss occurred when a third generator was being synchronised. During the vessel’s stay in Rotterdam, DNV GL simulated the conditions but could not replicate either blackouts.

The master, who was rightly concerned that CO₂ would enter the accommodation, instructed the third mate to shut down the accommodation fans. Although the third mate stated that he only pushed the button marked ‘ES-B’ (Figure 25), evidence⁶ indicated that actually ‘ES-C’ (cargo spaces) and then ES-A (engine- room space) had been activated as well.

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⁶ Engine alarm log.
This resulted in the shutdown of critical equipment necessary to operate the generators and main engine. Tests conducted in Rotterdam by DNV GL confirmed that there was no interlink between the three groups of switches and therefore, the only way the ‘ES-A’ stop was activated was by manual intervention.

The actions by the third mate had nothing to do with the validity of the goal, which was to stop the ventilation. The action was committed when he was trying to reach the goal – hence an attention error. However, errors are not random and occur as a response to causal factors.

As simple as the operation may seem to have been, it was carried out in a context which could have easily promoted potential error-producing factors – not least the prevailing situation on board, which was a non-technical issue. The MSIU therefore concluded that the error of pressing all the emergency stop buttons was local and transitory in nature.

It also has to be pointed out that the labels on the emergency stop buttons could have facilitated the wrong choice of the switch. For instance, whereas ‘ES-C’ was the switch...
to trip the ventilation in the cargo space, ‘ES-A’ was not the switch to trip the ventilation in the accommodation; ‘ES-A’ was the breaker trip to various critical equipment in the engine-room without which, neither the generators nor the main engine would run. Then, being an emergency stop switch box, once pressed, the operator would have no way back but to restart all the pumps and fans that would have been tripped.

The second blackout occurred when the third generator was being auto-synchronised by the third engineer and electrician. When DNV GL surveyors tried to replicate this failure with two generators in parallel and a third generator synchronising, they were unable to do so. Both the third engineer and the electrician stated that although the third generator was started in auto-mode, the synchronisation process was taking some time. Therefore, it is the view of the safety investigation that the engineers probably tried to synchronise the third generator manually as it was taking a long time in the auto mode, and in so doing, they may have attempted to close the circuit breaker (manually) when the generator was not actually synchronised with those already connected to the switchboard. The fact that there were no trips other than the generator main circuit breakers, and that all the generators continued to operate, would tend to support and confirm this analysis.

2.6 Loss of Starboard Fire Main

The main fire line was tested under pressure and witnessed by DNV GL and an owner’s representative, prior to the vessel’s delivery in May 2015. Therefore, the coupling should not have failed after approximately five months in service. However, a number factors have been identified that contributed to the failure of the coupling.

It was not excluded that the coupling was initially incorrectly tightened, and during the maiden voyages, flexing may have caused the coupling to work loose. Although the vessel reported using only one fire pump during fire-fighting, the coupling may have also come under excessive pressure at some stage when hydrants were being opened / closed, and caused it to slide by approximately 25 mm.

However, it is understood that after the accident, a modification to the pipeline was made because the gap between the two ends of the pipes that the coupling was connecting was larger than intended. This meant that the coupling was not gripping a sufficient area of the pipe and when pressure was applied, the coupling slipped. Added to that, photographs
taken by the crew suggested a piece of the gasket detaching from the main gasket. This could possibly indicate that the gasket had become damaged when it was initially installed and therefore contributed to its failure only after a few months of service.

2.7 Fire-Fighting Efforts

The fire-fighting efforts executed by the master and crew can be commended. Fire on board is a very serious matter, no matter how small. In the face of failure of equipment, which was designed to assist the crew members, they were able to contain and restrict the fire from spreading in the CH.

The success of the fire-fighting efforts was also attributed to a recent drill in which the crew members simulated a CH fire. When the general alarm was sounded on 07 September, they naturally followed what was taught to them and therefore the significance of conducting regular emergency drills should not be underestimated.
THE FOLLOWING CONCLUSIONS, SAFETY ACTIONS AND RECOMMENDATIONS SHALL IN NO CASE CREATE A PRESUMPTION OF BLAME OR LIABILITY. NEITHER ARE THEY BINDING NOR LISTED IN ANY ORDER OF PRIORITY.
3 CONCLUSIONS

Findings and safety factors are not listed in any order of priority.

3.1 Immediate Safety Factor

.1 The safety investigation could not determine the actual cause of the fire as the affected containers had been discharged before the investigation team boarded the vessel. However, it is thought that the containers located in or around the seat of the fire may have contained undeclared IMDG cargo.

3.2 Latent Conditions and other Safety Factors

.1 The CO₂ system failed to deliver the required quantity of gas into cargo hold no. 2 because of leaks in the system;

.2 Although the CO₂ system had been tested prior to the vessel’s delivery, neither the crew members nor the managers would have been able to identify the quality of the workmanship identified in the investigation;

.3 The starboard fire main line leaked during the fire-fighting and had to be isolated, which resulted in the starboard water drenching system becoming unusable.

.4 The coupling on the starboard fire main was incorrectly and/or poorly fitted;

.5 When the starboard fire line was isolated, it rendered the starboard water drenching system in the hatch covers unusable.

3.3 Other Findings

.1 An emergency stop switch was incorrectly activated that led to the shutdown of critical equipment necessary for the operation of the generators and main engine;

.2 The second blackout occurred because the third generator tripped when it was being manually synchronised;

.3 The connector hose between the hydrants and water drenching system were of different sizes, thus rendering the system unusable if any one side of the fire main line was affected.
4 ACTIONS TAKEN

4.1 Safety Actions Taken During the Course of the Safety Investigation

During the course of the safety investigation, the following measures were adopted by the Company:

1. A thorough inspection of all other in-service (newly built) vessels by the same approved service company which had conducted the inspection on board *Barzan* was carried out. All systems were checked for similar defects and all identified defects were promptly repaired and rectified.

2. Pressure testing of all CO\textsubscript{2} systems on newly built vessels to identify any leaks in the system.

3. Discussions with the shipyard and the Classification Society to identify issues in the workmanship and the testing procedures in place. Many changes were reported to have been made by the Yard and the Class to ensure that the similar defects are eliminated from ships which are either in the new built stage or in the process of being designed.

4. Immediately after the accident, a Fleet Circular was transmitted to all Company vessels, requesting that:

   - all masters, chief engineers and chief mates conduct a thorough inspection of the CO\textsubscript{2} fire-fighting system with respect to its readiness for immediate release in case of a fire and to report back to the Company;
   - cargo holds’ smoke detection system is checked and verified that it operates satisfactorily;
   - water spray systems (where fitted) are checked and verified that they are readily available;
   - cargo hold bilge alarms are checked and verified that they are readily available;
   - cargo hold bilge and pumping systems are checked and verified that they are readily available; and
   - details of the CO\textsubscript{2} system last inspection and blow-through of the CO\textsubscript{2} lines (as per planned maintenance requirements) are reported to the Company.
5. A Fleet-wide campaign has been launched to evaluate the readiness of the ship’s fire-fighting equipment and the effectiveness of the officers and ratings in handling a similar emergency situation on board their respective vessels. This necessitated that a drill is carried out on all vessels, relating to a scenario involving a fire inside a cargo hold and focusing on the following:

- response of the Ships Emergency Team;
- familiarisation with the CO₂ release mechanism for the cargo holds;
- familiarisation with the water spray system;
- boundary cooling and temperature measurement points - identification of locations which will be best suited for these purposes;
- hold bilges transfer to a ballast water tank to avoid pollution and environmental hazards;
- emergency communication with ‘Fleet Urgent’ and other authorities;
- record keeping and maintaining of an event log; and
- ease of use and immediate availability of fire-fighting and rescue equipment.
5  RECOMMENDATIONS

In view of the conclusions reached and taking into consideration the safety actions taken during the course of the safety investigation,

The Merchant Shipping Directorate is recommended to:

18/2016_R1  raise the fire-fighting equipment issues identified in this safety investigation report with the relevant recognised organisation acting on its behalf.

United Arab Shipping Company is recommended to:

18/2016_R2  disseminate the findings of this accident to its fleet.
LIST OF ANNEXES

Annex 1  A schematic diagram of the CO$_2$ fixed installation fire-fighting system

Annex 2  Instruction on the activation of the CO$_2$ fixed installation fire-fighting system
Annex 1  A schematic diagram of the CO2 fixed installation fire-fighting system
**INSTRUCTION CHART FOR CO2 FIRE EXTINGUISHING SYSTEM**

**IN THE EVENT OF FIRE**

**IN ENGINE ROOM**
- Go to the release control cabinet located at fire control station.

1. **KEY BOX**
   - Press the key.
   - Take the key.

2. **RELEASE CONTROL CABINET**
   - Open this door.
   - Alarm will be activated.
   - Ensure all personnel have vacated the protected space.
   - Close vents, doors and hatches & stop oil pumps & vent fans.
   - Open one pilot cylinder valve.
   - Open valve 1/01 & 1/02.
   - Vent fans will be stopped after main valve opened.
   - Now system is in operation.
   - In case of failure at fire control station, go to CO2 room immediately.

**IN CARGO HOLD**
- The smoke sampling system will detect the smoke in the actual hold on fire and a smoke alarm will be given from panel.
- Go to the control panel and identify the hold on fire.
- Go to the CO2 room and follow the instructions.

1. **CLOSE THE 2-WAY VALVE RELATING TO THE CARGO HOLD ON FIRE**
2. **MAKE SURE ALL PERSONNEL HAVE VACATED FROM THE PROTECTED SPACE**
3. **SHUT OFF THE VENTILATION AND HAS CLOSED ALL OPENINGS TO THE PROTECTED SPACE**
4. **GO TO THE CONTROL VALVE CABINET OF RELEVANT CARGO HOLD**
   - Open the door.
   - The alarm will be activated.
   - Close the loadings condition of the cargo hold on fire.
   - Open the ball valve no. 1.
   - Open the pump of relevant loadings condition.
5. **GO TO CONTROL CABINET FOR CARGO HOLD**
   - Open the cabinet door.
   - Open one pilot cylinder valve.
   - Open valve 1/01 & 1/02.
   - Now system is in operation.
6. **CO2 GAS WILL FLOW TO THE RELEVANT CARGO HOLD**
   - In case of malfunction, open the other pilot cylinder valve.

**EMERGENCY OPERATION**
**IN CARGO HOLD**
1. **IN PASSAGE WAY**
   - Open the selection valve relating to the cargo hold on fire.
2. **CLOSE THE 2-WAY BALL VALVE RELATING TO THE CARGO HOLD ON FIRE**
3. **GO TO THE MAIN VALVE FOR CARGO HOLD**
   - Rotating the control wheel.
   - Remove the safety pin.
   - Pull upward (down) the operating lever.
   - Hand wheel type.
   - Open by rotating the wheel to anti-clockwise.
4. **DO THE CYLINDER AND OPEN THE CYLINDER VALVE**
   - Remove the safety pin of the actuator fitted on cylinder valve.
   - Pull down the operating lever and the CO2 gas is discharged.
5. **TAKE SAME ACTION RAPIDLY FOR THE REQUIRED QUANTITIES OF CO2 CYLINDERS**
6. **NOW THE SYSTEM IS OPERATED.**

**AWAY FROM DISCHARGE**
1. **ALLOW ENOUGH TIME FOR THE CO2 GAS TO EXTINGUISH THE FIRE**
2. **DO NOT REOPEN THE SPACE UNTIL ALL REASONABLE PRECAUTIONS HAVE BEEN TAKEN TO ASSESS WHETHER THE FIRE IS OUT**
3. **WASH THE AREA IN WHICH THE FIRE OCCURRED AND THE SURROUNDING AREAS**
4. **PERSONS RE-ENTERING THE SPACE MUST WEAR AIR BREATHING APPARATUS UNTIL THE AMBIENT AIR HAS BEEN CHECKED AND REVERED TO 21% OF OXYGEN CONTENT.**

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**EMERGENCY OPERATION**
**IN ENGINE ROOM**
1. **IN CASE OF FAILURE IN SYSTEM OPERATION FROM THE CONTROL CABINET, GO TO THE CO2 ROOM**
2. **CONFIRM ALL VENT FANS STOPPED, DOORS AND HATCHES CLOSED**
3. **OPEN THE MAIN VALVE FOR CARGO HOLD**
   - Rotating the control wheel.
   - Remove the safety pin.
   - Pull upward (down) the operating lever.
   - Hand wheel type.
   - Open by rotating the wheel to anti-clockwise.
4. **DO THE CYLINDER AND OPEN THE CYLINDER VALVE**
   - Remove the safety pin of the actuator fitted on cylinder valve.
   - Pull down the operating lever and the CO2 gas is discharged.
5. **TAKE SAME ACTION RAPIDLY FOR THE REQUIRED QUANTITIES OF CO2 CYLINDERS**
6. **NOW THE SYSTEM IS OPERATED.**

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**MAIN VALVE HAND WHEEL TYPE**

**CYLINDER VALVE ACTUATOR**
1. **REMOVE SAFETY PIN**
2. **TAKE DOWN LEVER**

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**APPENDIX 2**
**INSTRUCTION ON THE ACTIVATION OF THE CO2 FIXED INSTALLATION FIRE-FIGHTING SYSTEM**