Marine Safety Investigation Unit

Transport Malta

SAFETY INVESTIGATION REPORT

202202/028 REPORT NO.: 03/2023 February 2023

MT *PEARL LNG*

Serious injury to three crew members
during maintenance work on the fire jockey hydrophore tank
in position 46° 53.9’ N 006° 41.2’ W
23 February 2022

The Merchant Shipping (Accident and Incident Safety Investigation) Regulations, 2011 prescribe that the sole objective of marine safety investigations carried out in accordance with the regulations, including analysis, conclusions, and recommendations, which either result from them or are part of the process thereof, shall be the prevention of future marine accidents and incidents through the ascertainment of causes, contributing factors and circumstances.

Moreover, it is not the purpose of marine safety investigations carried out in accordance with these regulations to apportion blame or determine civil and criminal liabilities.

NOTE

This report is not written with litigation in mind and pursuant to Regulation 13(7) of the Merchant Shipping (Accident and Incident Safety Investigation) Regulations, 2011, shall be inadmissible in any judicial proceedings whose purpose or one of whose purposes is to attribute or apportion liability or blame, unless, under prescribed conditions, a Court determines otherwise.

The report may therefore be misleading if used for purposes other than the promulgation of safety lessons.

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SUMMARY

Shortly after 1430 (LT) on 23 February 2022, three crew members on board the Maltese-registered LNG carrier *Pearl LNG*, were involved in an accident, about 185 nautical miles West Southwest of Saint Nazaire, France.

At the time, the crew members were attempting to remove an inspection cover on one of the vessel’s hydrophores, when the cover dislodged violently from the hydrophore.

The safety investigation established that the hydrophore was still pressurised when the cover was dislodged, with all its securing bolts removed.

Taking into consideration the safety actions implemented by the Company, no recommendations have been issued by the Marine Safety Investigation Unit (MSIU).

MT *Pearl LNG*

FACTUAL INFORMATION

Vessel

Pearl LNG was a 115,345 gt membrane-type LNG carrier, owned by Cardiff LNG Delta Owning LLC and managed by TMS Cardiff Gas Ltd., Greece (the Company). *Pearl LNG* was built by Samsung Heavy Industries Co., Republic of Korea, in 2019. American Bureau of Shipping (ABS) acted as the classification society as well as the recognised organization, in terms of the International Safety Management Code, for the vessel.

The vessel, which had a twin skeg and twin rudder design, had a length overall of 293.0 m and a moulded depth of 26.2 m. The vessel had a summer draft of 11.5 m, corresponding to a summer deadweight of 88,592.3 metric tonnes. At the time of the occurrence, *Pearl LNG* was on even keel, drawing forward and aft drafts of 11.3 m.

Propulsive power was provided by two 5-cylinder, two-stroke, slow speed, HSD W5X72DF, marine-dual fuel engines, each producing 11,350 kW at 74 rpm. Each main engine drove a fixed pitch, four-blade keyless propeller, to reach an estimated service speed of 19.5 knots.

Crew

Pearl LNG's Minimum Safe Manning Certificate stipulated a crew of 15[1]. At the time of the accident, the vessel was manned by 28 crew members from Croatia, Greece, the Philippines, Romania, and Ukraine. The three injured crew members were Greek nationals.

The second engineer was 33 years old. He started his seafaring career in 2014 as an engineer officer cadet until 2017, when he served on board for the first time as a third engineer. In 2021, he was promoted to a cargo engineer for 1.5 months, following which, he was promoted to second engineer.

The second engineer's Certificate of Competence was issued by the Greek authorities in April 2021. The second engineer, who had always served on LNG carriers, had signed four contracts with the Company as a third engineer but this was his first contract as a second engineer. He had joined the vessel on 03 November 2021 and had been serving as a second engineer for 3.67 months (up to the day of the accident).

The third engineer ($3/E_A$) was 35 years old. He had started his seafaring career in 2015 as an engineer officer cadet. His first trip on an LNG carrier was served on board this vessel, where he spent 3.5 months as a third engineer. He had embarked on *Pearl LNG* on 15 February 2022 and this trip was his second contract. The third engineer's Certificate of Competence was issued in 2020 by the Greek authorities.

Jockey pump

The vessel's fire main was fitted with a hydrophore and a jockey pump. Jockey pumps are low flow, but high-head pumps, whose function is to maintain the system pressurised, if there is a small pressure drop in the system, thereby preventing the main fire pump from starting[2]. The pump's capacity was 2.0 m^3hr^{-1} and designed for a maximum head of 90.0 m. The pump was driven by a 3-phase, 5.5 kW motor. The pressurised system was fitted with a conventional hydrophore (**Figure 2**).

The normal operating pressure range on the hydrophore was between 8.0 bar (jockey

[1] Unless the UMS and the bridge control were not operational.

[2] In case of activation of a sprinkler head / opening of a fire hydrant, the fire main would also experience a pressure drop. However, in such instances, the drop in pressure would be rapid and well beyond the capacity of the jockey pump. In that respect, the installation of the jockey pump will not compromise the timely start-up of the main fire pump, in case of a fire.

pump cuts in) and 9.0 bar (jockey pump cuts out).

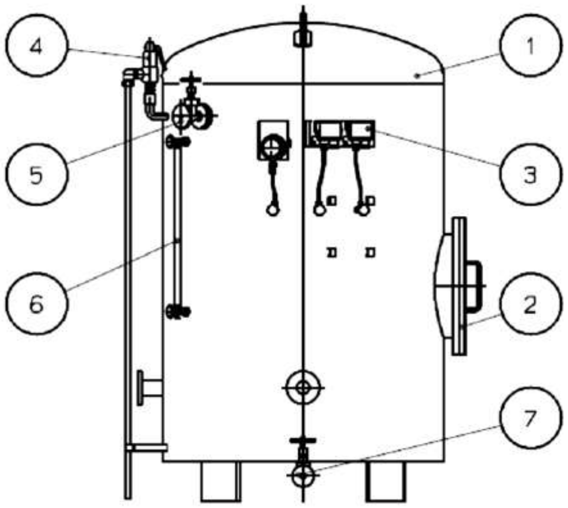

Figure 2: Hydrophore

The hydrophore tank had seven main design features:

- steel construction (1), epoxy coated and fitted with a manhole for inspection and cleaning (2);
- pressure switches to ensure that pre-set pressure levels are maintained (3);
- a safety valve (4), which opened at a pre-set value, but could be manually operated to safely reduce internal pressure;
- an air charge valve (5), which was only opened to charge the system with compressed air;
- a water level gauge to show the level of water inside the hydrophore (6); and
- a drain valve (7), normally closed and only opened when necessary.

The lower section of a hydrophore is normally filled with water. The quantity of water (hence, the volume) varies from one system to another, but it typically and approximately occupies half the internal volume of the hydrophore. Above the water level inside the hydrophore, is compressed air.

The operational principle of the hydrophore (**Figure 3**), is based on Boyle's law[3]. Changes in the volume of water inside the hydrophore will also affect the volume of the air above the water level, and hence its pressure. This fluctuation in the air pressure will operate the pressure switches (cut in and cut out), connected to the pumps.

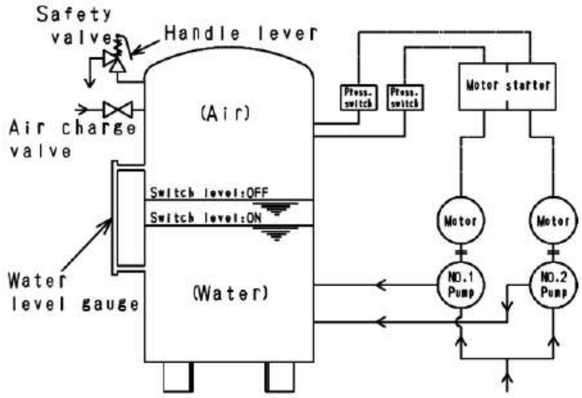

Figure 3: Hydrophore schematic

An entry on the jockey pump was made in the unscheduled jobs records of the vessel on 14 February 2022. The entry stated that during a routine inspection of the jockey pump, crew members observed that the discharge pressure was not exceeding 5.5 bar, whereas the normal pressure would be 8.5 bar.

Environment

At the time of the accident, the sky was overcast. A strong breeze was blowing from the Northwest. The sea was rough with a 4.0 m Westerly swell. The air and sea temperatures were 13 °C and 12 °C, respectively.

[3] The pressure of a fixed mass of gas is inversely proportional to the volume, provided that the temperature remains constant.

Narrative[4]

As for any other working day, on 23 February 2022, all the engine-room crew members met in the engine control room to discuss assigned jobs for the day. The task list for the day included the overhaul of the fire main's jockey pump and the internal inspection of the related hydrophore. Both tasks were assigned to the two third engineers ($3/E_A$ and $3/E_B$), who were requested to first isolate the system, disconnect the jockey pump, and then transfer it to the workshop, to be overhauled, cleaned, and boxed up again.

The dismantling process was uneventful, and the pump was isolated to be disconnected from the system. During the morning, the second engineer was in the area to check on the progress of the work on the jockey pump. In so doing, he proceeded to the hydrophore tank and opened the discharge valve to the fire line (**Figure 4**). As expected, as soon as he opened the valve, the water level inside the hydrophore tank dropped immediately, also observed through the sight glass. It was also recalled that the manometer indicated a drop in the internal pressure, to about one bar.

After closing the discharge valve again, the second engineer operated the hydrophore's safety valve[5]. No pressure was observed being relieved through the safety valve, leading the crew members to conclude that the hydrophore was at atmospheric pressure and therefore, the inspection cover was safe to open. The second engineer instructed the crew members to proceed with the opening of the hydrophore as soon as they complete the work on the jockey pump.

Soon after, the jockey pump was disconnected and engineer $3/E_B$ opened the drain valve (**Figure 4**).

Figure 4: Hydrophore showing the discharge valve (A) and drain valve (B)

Some water was observed escaping from the drain outlet. Considering the weight of the pump, engineer $3/E_A$ went to the engine-room workshop to get a strop, chain blocks and a trolley. Once on the trolley, the jockey pump was transferred to the workshop to be overhauled at a later stage.

By now, it was already 1000 and both third engineers left the area for their routine coffee break. Returning from the coffee break, engineer $3/E_A$ was requested by the chief and second engineers to assist in the overhaul of the gas oil separator in the purifier room. Engineer $3/E_A$ continued with his work in the purifier room until after lunch time, when he was relieved by another crew member.

By the time engineer $3/E_A$ was finished with his work in the purifier room, the inspection cover had not yet been removed. The second engineer, who was aware of the status of the task in hand, directed engineer $3/E_A$ not to delay the removal of the inspection cover. The third engineer acknowledged and

[4] Unless otherwise specified, all times are local (LT = UTC).

[5] The safety valve was set to operate at pre-set values of pressure. However, it also had a lever which allowed for the manual opening of the safety valve, should the need arise.

proceeded to the hydrophore area to remove the inspection cover.

Although all the bolts had already been removed, the third engineer's attempts to remove the inspection cover were futile. The inspection cover was too heavy for a single person to handle. He therefore approached the second engineer to inform him of the issue and that he would require assistance to remove the inspection cover.

The chief engineer, who was also in the area, overheard the discussion and instructed both engineers to join him in the engine-room, so that all three would remove the inspection cover. As soon as they arrived on site, the second engineer knelt down, holding the inspection cover from its lifting handles (**Figure 5**) and tight against his chest and abdomen. The chief engineer stood to the right of the second engineer, holding a hammer in hand. Engineer 3/E_A stood to the left of the second engineer.

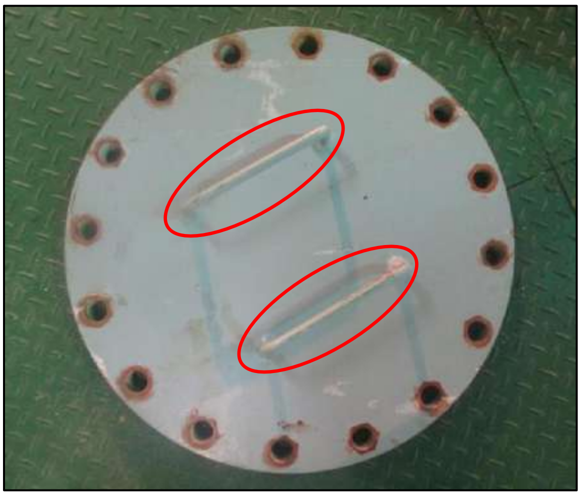

Figure 5: Inspection cover lifting handles

The chief engineer hammered the inspection cover hard to break the seal to the flange face on the hydrophore. Initially, the inspection cover did not dislodge. However, following either the second or third strike by the hammer, the inspection cover dislodged abruptly and forcefully. Still holding to the inspection cover, the second engineer was pushed several metres away from the hydrophore, until eventually he let go of the heavy inspection cover (**Figure 6**).

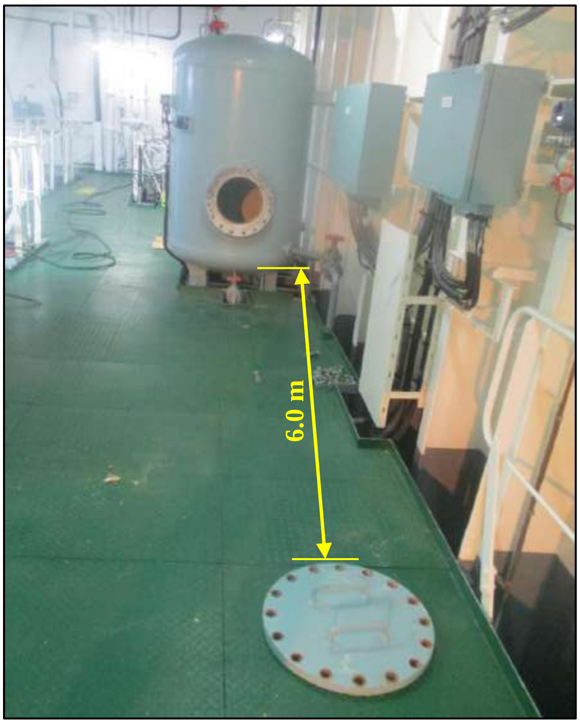

Figure 6: Position of the inspection cover after the accident

The third engineer, standing close by, was missed although the strong rush of air which he felt, contained some debris particles, which hit him in the eyes. The chief engineer was physically hit by the inspection cover, sustaining visible injuries to his leg.

Post-accident reactions

Composing himself again, but unable to see clearly, the third engineer approached the chief and second engineers lying on the floor plates. Both were unresponsive to his questions. Concerned, he made his way, as best as he could, to the engine control room, where he informed the gas engineer and the gas engineer trainee of what had just happened.

Notified of the accident, the master requested that the injured crew members be transferred to the vessel's hospital. The Company and

Red Cross were also informed, who advised the master to increase speed and alter course to the nearest coast, which was Brest, France. In the meantime, the Company had also initiated its emergency response team and contacted relevant entities and parties.

After reaching the area prescribed by the Rescue Coordination Centre, a helicopter was dispatched on site and five paramedics were lowered on board. Eventually, the injured crew members were transferred to a hospital in Brest, France. *Pearl LNG* proceeded to Montoir, France, to embark crew relievers.

Sustained injuries

The chief engineer sustained an injury to his left leg. The second engineer complained of pain in his leg, but a medical scan of his abdomen did not reveal any issues. The third engineer was diagnosed with foreign particles in his eyes and had a surgical intervention to rectify the issues.

All three crew members responded well to the administered medical treatment and have since then recovered.

ANALYSIS

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.

Dislodging of the inspection cover

It was immediately clear to the crew members that the 'violent' dislodging of the inspection cover could only be the result of a hydrophore whose internal pressure (behind the inspection cover) was higher than atmospheric pressure.

Taking into consideration the effective area of the inspection cover opening and the (residual) pressure inside the hydrophore, the force acting on the inspection cover at the time of the accident was approximately 2.74 tonnes-force (26.88 kN). This force (acting against the second engineer's chest as soon as the inspection cover was dislodged), was significant, considering also that the inspection cover weighed 54 kg.

The safety investigation concluded that prior to the removal of the inspection cover, the crew members used air to push the water out of the hydrophore but that was not enough to depressurise the vessel.

Residual pressure in the fire main

Pearl LNG was fitted with a pressure transducer on the fire main. The system also had the capability to record the pressure trends. The records for the time of the accident (**Figure 7**) were retrieved by the Company and forwarded to the safety investigation. It was pointed out that the pressure transducer was fitted after the hydrophore non-return discharge valve and as such, was isolated from the hydrophore tank because of the discharge valve between the hydrophore and the transducer.

It was noted that the pressure records indicated only 2.5 bar in the fire main at a very early time and before the accident happened (**Figure 7**). However, the system was working well, and the low pressure was merely because the jockey pump had been stopped for the scheduled overhaul later during the day. At 0830, the pressure card indicated a slight pressure peak inside the fire main, attributed to the moment the discharge valve on the hydrophore was opened to push the water inside the line. As soon as the level of water in the hydrophore tank dropped to the height of the discharge valve, air from the hydrophore escaped through the valve to the fire main, resulting in a 'false' reading of 0.5 bar.

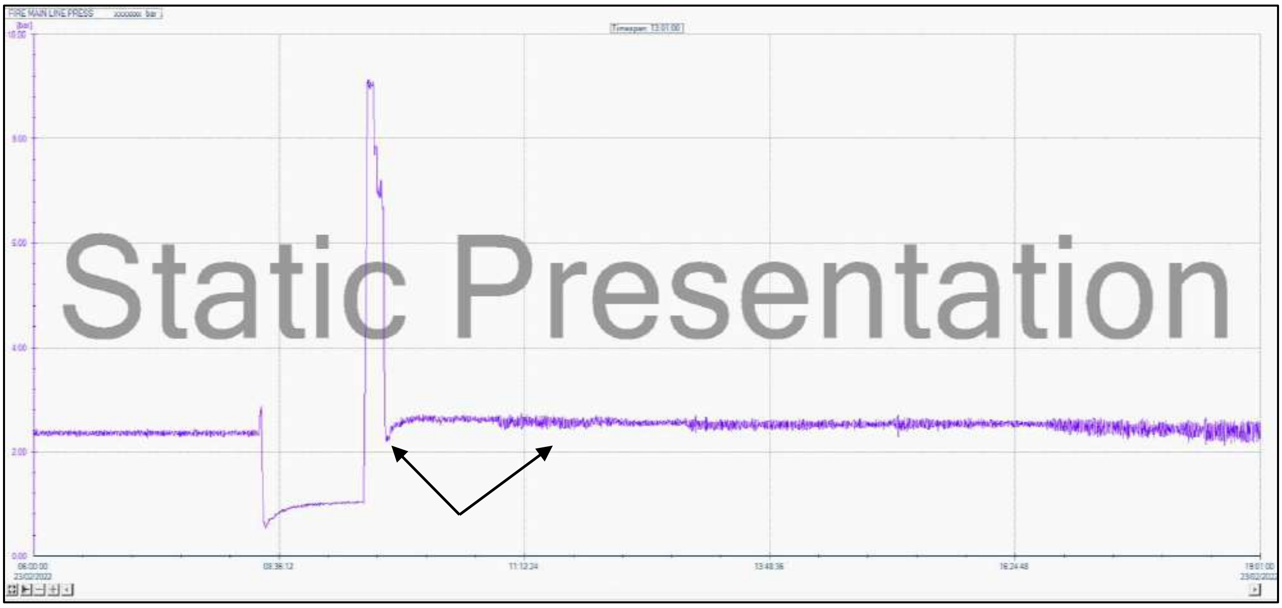

Figure 7: Pressure trend, showing a fire main pressure of approximately 2.5 bar (discharge valve was closed)

It was also noticed that at about 0930, the pressure in the fire main increased to 9.0 bars. This increase in pressure was due to the starting of the fire and general service pump when water was required on deck. The pump was only run for about 10 minutes, following which, it was stopped, and the pressure dropped again to 2.5 bar.

Pearl LNG had the anchor wash valves open[6]. Nonetheless, the pressure gauge still read 2.5 bar before the accident happened. This was attributed to the height between the engine-room flat, where the hydrophore was fitted, and the location of the main fire line on Deck A. The vessel's drawings showed that the difference in height was about 27 m, *i.e.*, the system had a water column of about 27 m, explaining the 2.5 bar of pressure read by the transmitter.

An efficient way to reduce the 2.5 bar pressure in the fire main was to open a fire hydrant in the engine-room (opening the drain valve on the hydrophore would not have helped because the hydrophore and the fire main were connected through a screw-down, non-return valve).

The information collected from the crew members did not indicate that a fire hydrant had been opened. Hence, the water column remained within the system.

Inspection of the pressure gauge and the safety valve

Following the accident, the pressure gauge on the hydrophore was tested and the copper pipe to the gauge inspected. The pressure gauge was found to be working well, and the test pressure reading on the scale was accurate. Moreover, the copper pipe leading to the pressure gauge was found free from debris and fully open.

During the inspection, the hydrophore drain line was also inspected and it was confirmed that it was fully open and had no blockage.

The hydrophore's safety valve (**Figure 8**) post-accident popping test confirmed that the valve was stuck in the closed position and did not open at the set pressure of 9.9 bar. In fact, the valve eventually opened at a pressure of 14.0 bar. It was also confirmed that manual release of the pressure through

6 Anchor wash is carried out by water lines fitted in the hawse pipes, supplied from the vessel's fire main.

the safety valve (by operating the attached lever) was not possible.

The safety investigation believes that the stuck guts of the safety valve did not contribute to the accident in a direct way. However, it misled the second engineer when he 'operated' the safety valve. Observing no relief of pressure (accompanied with a previous drop in the water level observed in the sight glass), he thought that the hydrophore was at atmospheric pressure and therefore safe for the engineers to open the inspection cover.

Figure 8: Safety valve to bilges

Inspection cover securing bolts

Information made available confirmed that all the nuts on the securing bolts had been released by the crew members. To the safety investigation, this indicated that the crew members were convinced that the hydrophore was perfectly safe to open[7].

The safety investigation report has provided information on the context which influenced the (local) decision-making process of the crew members to act and open the hydrophore tank. To this effect, it has been concluded that neither crew competence nor latent vessel defects were contributory to this occurrence.

Human performance

Information available did not indicate that the crew members were fatigued and not fit for work. Moreover, although no alcohol tests were carried out after the accident, the information available did not indicate that crew members were intoxicated. This was also confirmed from medical tests reports.

To this effect and noting that the behaviour of the crew members did not reflect any related issues, it was concluded that fatigue, alcohol, and drugs, were not contributory to the accident.

[7] During the safety investigation of this occurrence, the MSIU was notified of a similar occurrence on board the Maltese-registered passenger vessel *Celebrity Solstice*. In this latter case, a crew member removed all securing bolts of the valve cover for the second stage cylinder and tried to pry open the cover, using a screwdriver to investigate a malfunction in the two-stage, starting air compressor. While doing so, the cover violently dislodged and struck and injured the crew member in the abdomen. It was later found that the solenoid valve to drain the second stage cylinder was intermittently not opening as required when the compressor was stopped. As a result, the cylinder was still pressurized when the crew member pried it open.

CONCLUSIONS

1. The 'violent' dislodging of the inspection cover was the result of a pressurised hydrophore.
2. Prior to the removal of the inspection cover, the crew members used air to push the water out of the hydrophore but that was not enough to depressurise the vessel.
3. The hydrophore's safety valve post-accident popping test confirmed that the valve was stuck in the closed position and did not open at the set pressure of 9.9 bar.
4. Manual release of the pressure through the safety valve (by operating the attached lever) was not possible.
5. Observing no relief of pressure (accompanied with a previous drop in the water level observed in the sight glass), the engineer thought that the hydrophore was at atmospheric pressure and therefore safe for the engineers to open the inspection cover.

SAFETY ACTIONS TAKEN DURING THE COURSE OF THE SAFETY INVESTIGATION[8]

During the safety investigation, the Company has carried out an internal investigation in accordance with the relevant requirements of the ISM Code. Following the investigation, the Company:

1. sent a Fleet Notification on the occurrence and issued instructions, requiring office approval prior to maintenance works on pressure vessels;
2. has shared the investigation analysis and lessons learnt with the fleet and discussed them during the first monthly HSE meeting (on board and ashore) after the investigation was complete;
3. has included a detailed procedure for pressure vessels inspection and maintenance instructions in its Safety, Quality and Environmental Management System;
4. has carried out an internal audit on board the vessel;
5. has placed safety notices on all pressure vessels hatches to prevent improper dismantling and to ensure that safety bolts remain in place until de-pressurisation is completed;
6. has facilitated training and refresher courses to all crew members serving on board Company vessels;
7. has developed tailor made training programmes, driven by specific incidents to emphasize effective communication. The training programme is mandatory for all senior officers and must be completed within 12 months;
8. has implemented physical and virtual training to all crew members on effective communication, effective toolbox, and permit-to-work system;
9. has rescheduled the frequency of the safety valve operational test on the vessel's preventive maintenance system;
10. has re-evaluated the frequency of the planned engineering audits on all vessels in the fleet;
11. has requested a daily work planning meeting across the fleet to ensure planning of scheduled maintenance works;
12. has requested the use of eye protection during all maintenance tasks on deck and inside the engine-room; and

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

13. required that the company briefing form includes a discussion on the accident for a period of six months.

RECOMMENDATIONS

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

SHIP PARTICULARS	
Vessel Name:	*Pearl LNG*
Flag:	Malta
Classification Society:	American Bureau of Shipping (ABS)
IMO Number:	9862346
Type:	LNG Carrier (Type 2G)
Registered Owner:	Cardiff LNG Delta Owning LLC
Managers:	TMS Cardiff Gas Ltd.
Construction:	Steel – Double Hull
Length Overall:	293.10 m
Registered Length:	286.09 m
Gross Tonnage:	115,345
Minimum Safe Manning:	15
Authorised Cargo:	Liquified natural gas
VOYAGE PARTICULARS	
Port of Departure:	Montoir, France
Port of Arrival:	Milford Haven, UK
Type of Voyage:	Short International
Cargo Information:	164,947 m^3
Manning:	28
MARINE OCCURRENCE INFORMATION	
Date and Time:	23 February 2022 at 14:35 (LT)
Classification of Occurrence:	Serious Marine Casualty
Location of Occurrence:	46° 53.9’ N 006° 41.2’ W
Place on Board	Engine-room
Injuries / Fatalities:	Three injuries
Damage / Environmental Impact:	None
Ship Operation:	In Passage / Maintenance
Voyage Segment:	Transit
External & Internal Environment:	Overcast; Northwesterly strong breeze, rough sea with a 4.0 m Westerly swell; air and sea temperatures: 13 °C and 14 °C respectively
Persons on board:	28