# Final Report

## FIRE

## ONBOARD X-PRESS PEARL

## AT COLOMBO ANCHORAGE

## ON 20 MAY 2021

TIB/MAI/CAS.110

Transport Safety Investigation Bureau
Ministry of Transport
Singapore

16 October 2023

***The Transport Safety Investigation Bureau of Singapore***

*The Transport Safety Investigation Bureau (TSIB) is the air, marine and rail accidents and incidents investigation authority in Singapore. Its mission is to promote transport safety through the conduct of independent investigations into air, marine and rail accidents and incidents.*

*TSIB conducts marine safety investigations in accordance with the Casualty Investigation Code under SOLAS Regulation XI-1/6 adopted by the International Maritime Organization (IMO) Resolution MSC 255(84).*

*The sole objective of TSIB's marine safety investigations is the prevention of marine accidents and incidents. The safety investigations do not seek to apportion blame or liability. Accordingly, TSIB reports should not be used to assign blame or determine liability.*

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## ABBREVIATIONS

| | |
|---|---|
| **$CO_2$** | Carbon Dioxide |
| **$CO_2$ system** | $CO_2$ fixed fire-suppression system |
| **CTU Code**[1] | Cargo Transport Units Code |
| **DG** | Dangerous Goods |
| **DCP** | Dry Chemical Powder (medium to extinguish fire) |
| **DPA**[2] | Designated Person Ashore |
| **ECR** | Engine Control Room |
| **EmS Guide**[3] | Emergency Schedule Guide |
| **EPDM**[4] | Ethylene Propylene Diene Monomer |
| **E/R** | Engine Room |
| **ERT**[5] | Emergency Response Team |
| **ETA** | Estimated Time of Arrival |
| **FFE** | Fire Forensic Expert (engaged by the Company) |
| **FCS** | Fire Control Station |
| **FSS Code**[6] | International Code for Fire Safety Systems |
| **HFO** | Heavy Fuel Oil |

[1] The aim of this Code is to give advice to those responsible for the packing and securing of the cargo and used by those whose task is to train people to pack such cargo. The aim is also to outline theoretical details for packing and securing as well as to give practical measures to ensure the safe packing of cargo onto or into CTUs.

[2] According to the International Code for the Safe Management of Ships (ISM Code) as defined in SOLAS IX, as amended, to ensure the safe operation of each ship and to provide a link between the Company and those onboard, every Company, as appropriate, should designate a person or persons ashore having direct access to the highest level of management. The responsibility and authority of the designated person or persons should include monitoring the safety and pollution prevention aspects of the operation of each ship and ensuring that adequate resources and shore-based support are applied, as required.

[3] The EmS Guide contains guidance on Emergency Response Procedures for Ships Carrying Dangerous Goods and to be followed in case of incidents involving dangerous substances, materials or articles, or harmful substances (marine pollutants), regulated under the IMDG Code. *Source*: IMO.

[4] Saturated Polymer backbones exhibit superior resistance to heat, ozone, steam and weather. It is typically vulcanised with Sulphur. Versatile with broad usage in many industries as a seal and packing material. Can shrink at 212° F.

[5] Comprising senior management of Eastaway (the Company).

[6] Provides international standards of specific engineering specifications for fire safety systems required by Chapter II-2 of the International Convention for the Safety of Life at Sea (SOLAS), 1974, as amended. *Source*: FSS Code.

| | |
|---|---|
| **IBC**[7] | Intermediate Bulk Containers |
| **IMDG**[8] **Code** | International Maritime Dangerous Goods Code |
| **LMT**[9] | Local Mean Time |
| **LSA** | Life Saving Appliances |
| **MARPOL** | The International Convention for the Prevention of Pollution from ships, 1973 as modified by the Protocol of 1978 |
| **MDGF**[10] | Multimodal Dangerous Goods Form |
| **MEPA**[11] | Marine Environment Protection Authority |
| **MFAG**[12] | Medical First Aid Guide |
| **MSDS**[13] | Material Safety Data Sheet |
| **NM** | Nautical mile |
| **NVOCC** | Non-Vessel Operating Common Carrier[14] |
| **SCBA** | Self-Contained Breathing Apparatus |
| **SERS**[15] | Ship Emergency Response Service |
| **SMCP** | IMO Standard Marine Communication Phrases |
| **SMS** | Safety Management System |
| **SMT**[16] | Ship's Mean Time |

[7] Rigid or flexible portable packaging that are designed for mechanical handling and are resistant to the stresses produced in handling and transport, as determined by tests. *Source*: IMDG Code.
[8] As required by the International Convention for the Safety of Life at Sea, 1974 (SOLAS) Chapter VII. The IMDG Code is an international code for the maritime transport of DG in packaged form, developed to enhance and harmonise the safe carriage of DG and to prevent pollution to the environment. The IMDG Code sets out in detail the requirements applicable to each individual substance, material or article, covering matters such as packing, container traffic and stowage, with reference to the segregation of incompatible substances. *Source*: IMO.
[9] Local Mean Time (LMT) reflects the actual time on a meridian.
[10] A document required to be prepared and carried under the IMDG Code, which meets the requirements of SOLAS VII/4 [Carriage of Dangerous Goods > (Part A – Carriage of Dangerous Goods in Packaged Form) Documents].
[11] The Authority in Sri Lanka with law enforcement capabilities to deal with any act of marine environment pollution.
[12] For use in accidents involving DG.
[13] Required under the IMDG Code as a compliance for emergency response information; contains information related to the DG carried along with proper safety precautions.
[14] Operations comprises the sales, stuffing, and transport of the containers.
[15] Otherwise known as Rapid Response Damage Assessment under the Classification Society, responds to ship related emergencies and when activated, is an extension of the ship management team's own response capability.
[16] SMT are maintained onboard a ship and usually follows the LMT of the location or meridian.

| | |
|---|---|
| **SOLAS**[17] | International Convention for the Safety of Life at Sea (SOLAS), 1974 |
| **SOPEP** | Shipboard Oil Pollution Emergency Plan |
| **STCW** | International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978, as amended |
| **T.E.U.**[18] | Twenty-Foot Equivalent Unit |
| **UN** | United Nations |
| **UTC**[19] | Universal Coordinated Time |
| **WBT** | Water Ballast Tank |
| **XM** | X-Press Mekong (sister ship of XP) |
| **XP** | X-Press Pearl |

Table 1

[17] The main objective of the SOLAS Convention is to specify minimum standards for the construction, equipment and operation of ships, compatible with their safety. Flag States are responsible for ensuring that ships under their flag comply with its requirements, and a number of certificates are prescribed in the Convention as proof that this has been done. *Source*: IMO.

[18] Measurement reference to determine the cargo carrying capacity of the ship in standard 20-foot dimension containers.

[19] UTC is the primary time standard to which the world regulates clocks and time.

| Designation of personnel | Rank | Department |
|---|---|---|
| Chief Officer | CO | Deck |
| Additional Chief Officer | A-CO | |
| Second Officer | 2O[20] | |
| Additional Second Officer | A-2O | |
| Third Officer | 3O[21] | |
| Bosun | BSN[22] | |
| Able Seafarer Deck | ASD | |
| Officer of the Watch | OOW | |
| Ordinary Seaman | OS[23] | |
| Chief Engineer | CE | Engine |
| Second Engineer | 2E | |
| Additional Second Engineer | A-2E | |
| Third Engineer | 3E | |
| Electrical Officer | EO[24] | |
| Messman | MSM | Galley |

Table 2

[20] 2O's cargo watch in port was from 0001-0600H, and 1200-1800H. 2O's navigation watch at sea was from 0001-0400H, and 1200-1600H.
[21] 3O's cargo watch in port was from 0600-1200H, and 1800-2400H. 3O's navigation watch at sea was from 0800-000H and 2000-2400H.
[22] Member of the Deck department who supervised deck crew.
[23] Member of the Deck department and the starting rank of a seafarer.
[24] The EO was part of the shipboard team which delivered XP from the shipyard in China in February 2021.

## SYNOPSIS

On 20 May 2021 at about 1030H (Local Time), the Singapore registered container ship X-Press Pearl (XP), which was carrying 1,486 containers, encountered a fire that started in the cargo area while at anchor about nine nautical miles from the Port of Colombo, Sri Lanka.

The crew of XP responded to fight the fire by commencing boundary cooling and subsequently released of carbon dioxide ($CO_2$). A 12-man team of salvors boarded XP on the 23 May 2021 and took over the firefighting command and control onboard XP from the Master and crew and coordinated the efforts with tugs dispatched by the port authority and other assets.

Over the next few days, the weather deteriorated which resulted in the fire spreading to other cargo areas, accommodation, and the engine room. XP was abandoned on the morning of 25 May 2021 and was subsequently declared a total loss.

The Transport Safety Investigation Bureau classified the occurrence as a very serious marine casualty.

As most of the evidence was destroyed by fire, the investigation team was not able to conclusively determine the cause of the fire. However, from the events leading up to the fire, it was determined that the fire had likely started from one container carrying Nitric Acid (Class 8 - corrosive substance with a subsidiary risk of Class 5.1 - oxidising substance), which was reported as leaking about 10 days prior to the fire.

The investigation team noted that the Master's request to offload the leaked container at the two ports before Colombo were unsuccessful, as the ports cited either insufficient information provided for handling the leaked container or insufficient capability to handle a leaking container of Nitric Acid.

The following are the key findings, amongst others –

a) At the Port of Jebel Ali, another container, *GESU2837027,* was supposed to be transported together with the incident container, *FSCU7712264*. Container *GESU2837027* was transferred to the inspection yard as it was found with leaking Nitric Acid. It was later discovered that the IBCs storing the Nitric Acid were in poorly stacked and packed condition and the manufacturing dates of

the IBCs were unknown. As both containers *GESU2837027* and *FSCU7712264* were stacked and packed by the same Exporter, the IBCs storing the Nitric Acid inside container *FSCU7712264* were likely to be in a similar poor condition and could have contributed to the leaking of Nitric Acid. The requirements of the CTU Code and the IMDG Code had not been complied with.

b) After discovering the leak of container FSCU7712264 onboard XP, the crew did not check details of the cargo and proceeded to use sawdust to manage the leak. Although some water was used initially to dilute the concentration of Nitric Acid, the use of inert absorbent pads was not considered to manage the leak.

c) The bad weather conditions experienced by XP prior to arriving Colombo did not allow for the leak to be actively monitored which could have become worse due to the rolling and pitching encountered by XP. As a result, the leaked Nitric Acid had not been washed overboard and could have made its way down into cargo hold #2.

d) The leaked Nitric Acid (concentration of which was not accurately known) being highly corrosive with oxidising properties, had likely interacted with various metals and materials resulting in subsequent exothermic reactions which compromised the rubber seals of the containers in the vicinity, and other DG or non-DG containers inside cargo hold #2 and resulted in fire.

e) The information on the leak of Nitric Acid from container *GESU2837027,* which was intended to be loaded onboard XP with the incident container, *FSCU7712264,* was not made known to the Operator which could either have prevented it from loading onboard XP or have facilitated it to be offloaded expeditiously from XP when the leak was detected.

f) After the leak of Nitric Acid was detected, there appeared to be a lack of coordinated efforts to off-load container *FSCU7712264* expeditiously for the safety of the crew and the ship.

g) The cargo hold was not fully sealed prior to the release of the $CO_2$ and the ship's crew released the entire $CO_2$ in one discharge, instead of the recommended amount of $CO_2$ to be released based on the loading condition of the cargo hold.

h) XP's muster list was not used to manage the manpower resources effectively.

The command and control in handling the emergency could have been better as the on-signers being new onboard were managing the response by randomly allocating crew to respond to the emergency. The off-signers, who were still onboard and more familiar with XP, were only used for boundary cooling in the early stage, but they were not assigned to specific roles, and later were unwilling to participate in the firefighting efforts.

i) The salvors had limited time to assess the situation and were unable to orientate XP's bow to a position that could minimise the fanning of the fire by the prevailing winds, causing the fire to rapidly spread aft and towards the accommodation and engine room. As a result of this rapid spread, the crew were unable to use the designated means of escape such as the freefall lifeboat to abandon ship.

j) The response from Colombo Port Control to assist XP for managing the emergency was deemed limited. There was no follow-up after a team of firemen from ashore had assessed the situation onboard XP. The tugs sent for firefighting had various limitations and the port did not offer continuous firefighting support.

k) The VDR data for the occurrence was not available to the investigation team which could have provided insights to the development of the emergency and the response by shoreside personnel.

**VIEW OF SHIP**

Figure 1 - Aerial view of X-Press Pearl taken on 21 May 2021 - *Source:* Hiru News Sri Lanka

## DETAILS OF SHIP

| | |
|---|---|
| Name of ship | X-PRESS PEARL (XP) |
| IMO Number | 9875343 |
| Licence No. | 9V6962 |
| Classification Society | American Bureau of Shipping (ABS) |
| Ship Type | Container |
| Keel Laid/ Delivered | December 2015/ February 2021 |
| Feeder Services (Operator) | X-Press Feeders[25] |
| Company[26] | Eastaway Ship Management Pte. Ltd. |
| Freight Forwarder/ Shipper[27] | Transvision Sea Shipping Lines[28] |
| Gross Tonnage | 31,629 |
| Container Capacity. | 2,756 TEUs |
| Reefer Container Capacity | 400 TEUs |
| Length Overall | 186.0m |
| Breadth | 34.8m |
| Designed Draft | 17.9m |
| Summer Freeboard | 6.925m |
| Main Engine(s) | CSE - MAN B&W, 6G60ME-C9.5, MCR 16080kWx97Rpm; 2019 |
| Propellers | One fixed pitch propeller 5 blades, right-handed, Ø 7.2m |

[25] Feeder Services operated by Sea Consortium Pte Ltd, herewith referred as X-Press Feeders.
[26] Company means the owner of the ship or any other organisation or person such as the manager, or the bareboat charterer, who has assumed the responsibility for operation of the ship from the shipowner and who, on assuming such responsibility, has agreed to take over all duties and responsibility imposed by the ISM Code. *Source*: ISM Code. Eastaway Ship Management Pte. Ltd (the Company) managed six ships at the time of occurrence.
[27] Shipper is a person or company or entity that is shown in all shipping documents (bill of lading, packing list) as the party that enters a contract of carriage with a carrier. Shipper also known as consignor.
[28] Had their operations in United Arab Emirates (UAE) and India. As a NVOCC, offers sound empty containers for the exporter (shipper of the cargo) to load the intended cargo and label them according to the hazardous DG class. As a Freight Forwarder, accepts booking from the exporter, arranges for the booking slot on the ship, and processes the shipment documents in consultation with the Operator. For this report, 'Shipper' will be used.

<table>
<tr><td>LSA Capacity</td><td colspan="3">26 pax</td></tr>
<tr><td>Muster Station</td><td colspan="3">Aft of ‘B’ deck</td></tr>
<tr><td>Lifeboat Arrangement</td><td colspan="3">26 pax totally enclosed free-fall lifeboat at the stern</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td>Fixed Firefighting System</td><td colspan="3">Comprises 175 high pressure $CO_2$ bottles[29] in the $CO_2$ Room that provides protection to the E/R area and cargo hold spaces</td></tr>
<tr><td rowspan="4">Portable Fire Extinguishers</td><td>Medium</td><td>Capacity</td><td>Quantity</td></tr>
<tr><td>$CO_2$</td><td>5kg</td><td>8</td></tr>
<tr><td>DCP</td><td>6kg</td><td>44</td></tr>
<tr><td>Foam</td><td>9 litres</td><td>12</td></tr>
<tr><td>Remote Release Station for $CO_2$</td><td colspan="3">Fire Control Station and $CO_2$ Room</td></tr>
<tr><td>SCBA Compressor</td><td colspan="3">Emergency Generator Room located at ‘A’ deck for charging SCBA bottles</td></tr>
<tr><td>Fireman’s Outfit</td><td colspan="3">Two sets – protective clothing, pair of boots and gloves, helmet, electric safety lamp, fire axe, SCBA, lifeline with snap hook, 3 spare bottles.<br>One set located in the Safety Store on ‘A’ deck.<br>One set located in the Fire Control Station on the Upper deck</td></tr>
<tr><td>Chemical Protective Outfit</td><td colspan="3">Two sets – gas-chemical protective suit, chemical protective suit, pair of boots and gloves, protective visor, SCBA with spare air tank, 2 spare bottles.<br>Both sets located in the Fire Control Station on the Upper deck</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td>Cargo Cranes[30]</td><td colspan="3">Three – one behind bay 6, one behind bay 22, one behind bay 30</td></tr>
<tr><td>Safe Working Load and outreach of cargo crane</td><td colspan="3">• 45t x 25m</td></tr>
</table>

[29] Main $CO_2$ bottle contain 45kg of carbon dioxide in liquid state at a pressure of 56 bar meeting SOLAS requirement for fixed gas ($CO_2$) fire-extinguishing system of general cargo required on cargo ships of 2,000GT and above. The fixed $CO_2$ system fitted onboard XP comprised 175 bottles high pressure $CO_2$. Refer to **para 1.5** for description/ operation of the fixed $CO_2$ system.

[30] XP was not provided with spreader and/ or wire slings to facilitate loading/ discharge of containers where shore cranes are not available.

| | |
|---|---|
| | • 36t x 30.5m |
| | |
| Cargo hold ventilation flaps | • 227 (total) manual closing devices for ventilation inlet or outlet |
| Mechanical fans | Cargo hold #2 – 10 fans forward and 10 fans aft of hold |
| Smoke detector | 31 units monitoring cargo holds |
| Passageway arrangements | Passageway to each cargo hold is separated by a watertight door, and fitted with water fire hydrant and dual-purpose type fire hose (Ø 50mm x 18m) and nozzle (spray/ jet type) on port and starboard side respectively |

Table 3

# 1 FACTUAL INFORMATION

All times used in this report are ship mean time (SMT) which corresponds to the local mean time (LMT) where the ship is located. For reference, the LMT is listed below:

- Port of Jebel Ali, United Arab Emirates is four hours ahead of UTC.
- Port of Hamad, Qatar is three hours ahead of UTC.
- Port of Hazira, India and Port of Colombo, Sri Lanka are five and half hours ahead of UTC.

In the conduct of marine safety investigation into the circumstances surrounding the fire onboard XP and its subsequent total loss, except for the VDR[31], the investigation team reviewed information obtained from the Company, the Operator, the Shipper, interviews of the Master and crew and other sources.

## 1.1 Narrative

1.1.1 On 10 May 2021, XP arrived at Port of Jebel Ali around noon. After completing the arrival port formalities, before commencement of cargo operations, the CO received information about the planned cargo loading which, amongst others, included the quantity, weight, and stowage location of each container, the different types of containers such as reefer, out of gauge (outsize), DG containers, etc.

1.1.2 The investigation team gathered that the CO input the cargo information into the ship's cargo computer system for stability calculations, referred to as MACS3 software. The software, besides providing information on ship's stability, had the provisions to check the stowage of DG containers and their compliance with the Class approved Document of Compliance "Special Requirement for Ships Carrying Dangerous Goods".

1.1.3 During XP's port stay in Jebel Ali, MACS3 software did not indicate any stowage abnormalities or conflicts between DG containers planned to be

[31] Requests to the Coastal State were unsuccessful due to judicial process in the aftermath of the occurrence.

loaded and those that were onboard.

1.1.4 On completion of cargo operations, XP departed for Hamad, Qatar, at about 1500H. During the voyage from Port Jebel Ali to Hamad Pilot station, the weather and sea state was moderate.

1.1.5 At Port of Hamad

1.1.5.1 On 11 May 2021 at about 0330H, XP arrived at Hamad Pilot station. According to the Master, he became aware of a leak from a container on deck at position 110582[32], that had been loaded at Jebel Ali, as reported by the ASD-3 when XP was picking up Pilot.

1.1.5.2 The Master, upon confirming the leak from the container (ID *FSCU7712264*, hereinafter referred to as container *FSCU7712264*), checked the Packing List, DG manifest and the MSDS (all of which were provided by the Shipper), indicating that the content was about 29 metric tonnes of Nitric Acid. The Master called the Operator on the mobile phone around 0530H informing about the leak. XP was all fast at the berth at 0536H. After completing all the port formalities and checks, cargo operation commenced at about 0600H.

1.1.5.3 At about 0900H, while the cargo operation was underway, the duty officer on deck (3O) noted a green liquid around container *FSCU7712264* with no visible damage to the exterior of the container. There was a strong chemical smell in the area. The 3O took some photos of the container and showed it to the CO.

1.1.5.4 Bubbling of the paint on the hatch cover was noted and documented, see **figures 2 and 3** below showing the extent of leak. The rate of leak was assessed to be about 0.5 - 1 litre/ hour. Container *FSCU7712264* had the placards showing IMDG Class 8 and Class 5.1.

[32] Cargo hold #2 comprised bays 10 and 14 for 40-foot containers, bays 9, 11, 13 and 15 were for 20-foot containers. Position 110582 means bay 11, row 05 (numbered from centerline to maximum of 7 rows on either side and naming even numbers to port and odd numbers to starboard), and tier 82 means on deck which begins from tier 82 up to tier 90 with a maximum of five tiers, while inside cargo hold begins at tier 02 from the bottom of the cargo hold up to tier 12 below the hatch cover).

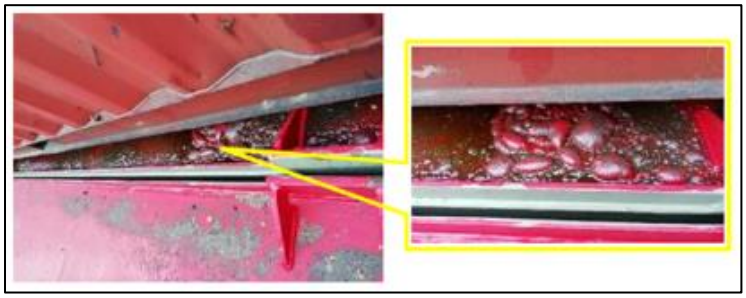


Figure 2 - Bubbling of hatch cover paint underneath container *FSCU7712264* - *Source:* The Company *(annotation in yellow by TSIB)*

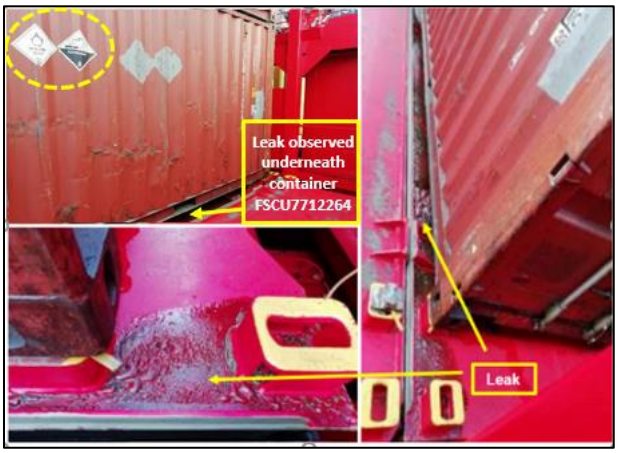



Figure 3 - Indicating leaked cargo observed underneath container and labelling of Primary (Corrosive) with Subsidiary risk (Oxidising agent) - *Source:* The Company *(annotations by TSIB)*

1.1.5.5 The CO instructed the BSN and OS-2 to stop the spread of the leaking cargo with sawdust[33] and to rinse the area with seawater using fire hoses.

1.1.5.6 The BSN and OS-2 used sawdust to minimise the spread of the leak. Thereafter, a fire hose was rigged to wash down the remnants. However, soon after commencing the wash, the crew were stopped by shore workers

[33] Typically forms a part of Shipboard Oil Pollution Emergency Plan (SOPEP). MARPOL Annex I requires that all ships of 400GT and above to carry an approved SOPEP. Sawdust is organic and is combustible in nature. According to the Company, XP's SOPEP also had, among others, included 4 bags (100 Ltrs/ bag) of absorbent granules and 400 pcs (450mm x 450mm) absorbent sheets, bags of absorbent pads / booms, and material. The investigation team gathered that these materials were not used to soak up the leak.

informing that the cargo operation was still ongoing, and the wash water could flow overboard onto the berth and port waters.

1.1.5.7 The BSN reported the prohibition[34] of hosing down in the port to the CO and was instructed to use more sawdust and to constantly monitor the situation. The crew used more sawdust and reportedly cleaned up the soaked sawdust and stored the soaked sawdust in waste receptacles which were then placed near the ship's garbage collection area at the poop deck. The CO also filed a damage report[35] in accordance with the SMS.

1.1.5.8 The Master followed up with the Operator and Shipper stating that the leaking container had heavily corroded the hatch cover, seeking guidance for it to be offloaded[36] or whether it was to be carried till Port Klang, Malaysia.

1.1.5.9 Around noon, the Master also sent a follow-up email with pictures to the Shipper's Operations department in Dubai and Singapore, copying the DPA, the appointed agent in Hamad, and the container terminal informing them of the leaking DG container, requesting for an urgent offloading.

1.1.5.10 A copy of the MSDS and Packing List was provided upon request by the appointed agent in Hamad for processing the formalities to offload container *FSCU7712264*.

1.1.5.11 It was further established by the investigation team that during the day, while cargo operation was ongoing, in response to the Master's query whether container *FSCU7712264* would be retained till Port Klang, the Operator instructed the Shipper to offload the container. The Shipper responded that the agent had been requested to do the needful.

1.1.5.12 The investigation team also noted from the email exchanges among the container terminal, the Company, the Operator, the appointed agents, and XP in the circulation list, the Company had also requested the container terminal, to offload container *FSCU7712264*.

[34] May have breached environmental regulations and attracting fines and/ or sanctions.
[35] The damage report was primarily intended to protect the Company from liability in the event the damage to the container or its cargo was caused by the ship.
[36] Offload for the purpose of reworking and to make the container seaworthy before being shipped.

1.1.5.13 The Operator (with others in copy) subsequently received advice from the container terminal representative that container *FSCU7712264* could not be offloaded as its destination was not Hamad Port and further approval would be needed from the Ministry of Municipality and Environment. Restrictions on storing some of the commodities in the yard were cited as well as a part of the process to handle leakage, and that the consignee was to arrange the relevant tanks, and protective equipment related to the leaking commodities, which was not communicated to the terminal representative at the time of the request.

1.1.5.14 After a few hours, the Shipper responded to the Operator that the offloading of container *FSCU7712264* was not possible due to Ramadan holidays and timing (as XP was scheduled to depart in an hour), and counter proposed for the container to be offloaded at the Port of Hazira. The Company informed the investigation team that they reluctantly accepted that the offloading of the container was not possible at the Port of Hamad and initiated attempts to arrange the offloading at the next port.

1.1.5.15 The investigation team further gathered that container *FSCU7712264* remained onboard XP at the Port of Hamad and efforts were then initiated for it to be offloaded in Hazira. At about 2300H, XP departed the Port of Hamad for Hazira, India.

1.1.6 En-route from Hamad to Hazira

1.1.6.1 After departure from the Port of Hamad and clear from the Gulf Special Area[37], the CO instructed the BSN to rig two fire hoses – one forward and one aft of container *FSCU7712264* to hose down the leaked Nitric Acid with seawater into the sea[38]. The hoses were running continuously in the hours of the night. XP was listed by about two degrees to starboard to enable the effluents to

[37]MARPOL Annex I and V for Gulf Special Areas.

[38]Cargo residues as defined in Annex V of the MARPOL Convention means the remnants of any cargo which are not covered by other Annexes to the present Convention and which remain on the deck or in holds following loading or unloading, including loading and unloading excess or spillage, whether in wet or dry condition or entrained in wash water but does not include cargo dust remaining on the deck after sweeping or dust on the external surfaces of the ship. Discharge of cargo residues is prohibited in the area the ship was transiting at the material time. According to the Flag Administration, the contents referenced are not considered as a cargo residue under Annex V of MARPOL but categorised under Annex III of the MARPOL Convention. Under Annex III, appropriate measures based on the physical, chemical and biological properties of harmful substances shall be taken to regulate the washing of leakages overboard, provided that compliance with such measures would not impair the safety of the ship and persons onboard (Regulation 8 – Exceptions). Nitric Acid is not classified as a marine pollutant.

easily flow into the sea.

1.1.6.2 During the voyage to Hazira, the CO conducted daily checks on deck which included monitoring the condition of container *FSCU7712264.* The CO had also arranged for the two OS to monitor[39] the leak on a two hourly basis. According to the CO the rate of leak remained to be about 0.5 – 1 litre/ hour.

1.1.6.3 On being asked, the CO responded that to facilitate ventilation of cargo hold(s) carrying DG cargo, mechanical ventilation fans were running at the time, and natural ventilation flaps were kept open.

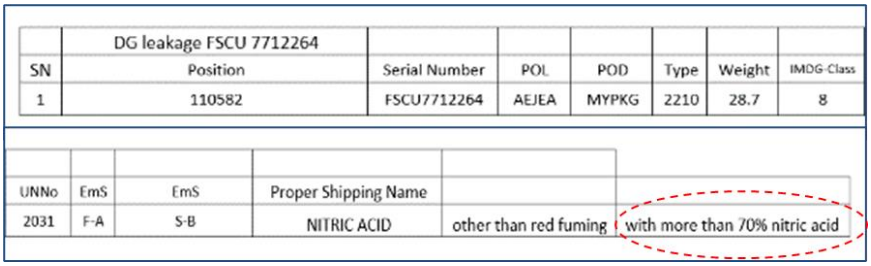
1.1.6.4 On the morning of 13 May 2021, the CO, while at the Ship's Office, was alerted by a high-level bilge alarm from cargo hold #2. The CO entered cargo hold #2 and saw that the aft bilge wells (port and starboard side) were full of water. A small amount of water was also observed at the tank top, but the bottom of the containers was not affected by the water.

1.1.6.5 The CO then instructed the engineers to pump out the bilge water and the bilge wells were emptied on the same day. The CO further recalled that during this time there was no chemical smell inside cargo hold #2. The CO opined that the wash water used to hose down the leaked Nitric Acid (effluents) on the hatch cover could have flowed down into cargo hold #2 through the gaps of the hatch covers (see **section 1.4** – Design of XP).

1.1.6.6 According to the Company, on the same day afternoon, orange/ light yellow smoke was observed coming from container *FSCU7712264* and the matter was surfaced to the Operator and relevant agents, indicating that the hatch cover was heavily corroded by the leaking Nitric Acid.

1.1.6.7 The investigation team sighted further email[40] exchanges involving the Shipper, the appointed agents in Hamad and Hazira, prior to XP's arrival regarding the offloading of container *FSCU7712264*. See **table 4** with additional information provided about container *FSCU7712264* to the agent in Hazira.

[39] The ASDs were not involved in monitoring as they were keeping bridge watchkeeping (look-out) duties due to density of fishing boats in the vicinity.
[40] Initiated on 11 May 2021 by the Shipper at the request of the Operator.



| | DG leakage FSCU 7712264 | | | | | | |
|---|---|---|---|---|---|---|---|
| SN | Position | Serial Number | POL | POD | Type | Weight | IMDG-Class |
| 1 | 110582 | FSCU7712264 | AEJEA | MYPKG | 2210 | 28.7 | 8 |

| | | | | | |
|---|---|---|---|---|---|
| UNNo | EmS | EmS | Proper Shipping Name | | |
| 2031 | F-A | S-B | NITRIC ACID | other than red fuming | with more than 70% nitric acid |

Table 4

1.1.6.8 The agent in Hazira responded to the Operator and XP that according to the terminal's advice, they were not allowed to offload container *FSCU7712264* at Hazira Port as the terminal was unable to handle[41] a leaking container and reworking the container would be difficult to permit.

1.1.6.9 On 15 May 2021 prior to arriving Hazira, noting that the leak had stopped, the CO instructed the crew to stop hosing down the area around container *FSCU7712264*. On reporting the status of the leak to the Master, the CO was instructed to secure the fire hoses.

1.1.7 At Port of Hazira

1.1.7.1 XP arrived the Port of Hazira on 15 May 2021 at about noon. Cargo operation commenced at about 1300H.

1.1.7.2 While at the Port of Hazira, as a part of routine crew change, five on-signers (A-CO, A-2O, A-2E, A-3E and A-MSM) embarked XP. The intention was for these five additional crew to sail with XP and later to relieve the respective existing crew, who were scheduled to sign-off at the next port, Port of Colombo, Sri Lanka.

1.1.7.3 The investigation team gathered from the A-CO that he was informed by the Master of the leak from container *FSCU7712264* and the unsuccessful efforts to offload it in Hamad and Hazira. The A-CO was also made aware of the contents of the cargo within this container. The A-CO confirmed that during his deck inspection prior to XP's departure from Hazira, there was no leak or smoke, but the condition of the hatch cover on bay 11 was similar to what had

[41] Assessment reportedly made based on the extent of heavy leakage on the deck of XP, as it would affect the terminal property.

been reported earlier.

1.1.7.4 The A-CO recalled checking with the Master on what actions or precautions had been taken earlier and understood that the area in the vicinity of container *FSCU7712264* was cleaned up using sawdust and sea water.

1.1.7.5 According to the information provided to the investigation team, when XP was berthed at the Port of Hazira, there was no inspection/ verification of container *FSCU7712264* by the shore personnel, and there was no further correspondence regarding its status. According to the Master, departing on schedule was one of the considerations to ensure safety of XP in view of the approaching cyclone, Tauktae[42].

1.1.7.6 At about 1900H, XP departed Hazira, as scheduled, bound for Colombo.

1.1.7.7 For the ensuing passage to Colombo, the Master deviated XP's route further to the west to maintain sufficient distance away from the cyclone's expected path, before continuing the planned route along the west coast of India.

1.1.7.8 The A-CO[43] shared that, after departing Hazira, due to rough seas and strong winds, routine deck work[44] assigned by the CO were near the accommodation and nothing at forward or in the vicinity of bay 11, where container *FSCU7712264* was stowed.

1.1.7.9 The investigation team sighted emails dated 17 and 18 May 2021 from the Master to the Operator, Shipper and Company advising them of the rate of leakage estimate to be between 0.5 to 1 litre per hour. The A-CO recalled that he noted the leak from container *FSCU7712264* again on 19 May 2021.

1.1.7.10 Thereafter, on 19 May 2021, there was correspondence for offloading container *FSCU7712264* in Singapore, which included seeking approvals from the relevant authorities in Singapore. The Master updated all parties that the

[42] Cyclone Tauktae has been classified by NOAA as a Category 4 cyclone with maximum sustained wind of 135mph. At that time, the cyclone, moving northward was about 800 km south of the Port of Hazira. It was expected to make landfall on 17 May 2021. It is usually recommended for ships in port to proceed out to sea when a cyclone is approaching.

[43] Accordingly, the handing/ taking over duties and responsibilities between the existing CO and newly joined A-CO was carried-out while the vessel was on passage from Hazira to Colombo. It was the same for the rest of the newly joined crew.

[44] Cosmetic upkeep of the ship, including painting and greasing.

leak was about 0.5 litre per hour, that the container was continuously emitting orange smoke since 11 May 2021 and the IBCs inside could be heard falling. Upon receiving the Master's update, the Superintendent called the Master on the phone to get further clarification. The Superintendent followed up with an email requesting for some photographs while stating his assessment of the verbal update that the orange smoke (see **figure 4**) was probably due to corrosion effect and that there was no risk of fire. In the same email, the Superintendent further requested the Operator to check the possibility of offloading container *FSCU7712264* at the port of Colombo, ETA Colombo on 19 May 2021.

1.1.7.11 The investigation team further established from the Master's response to the Superintendent's email that container *FSCU7712264* had been producing orange smoke for some 10 days, reasons for which could not be established as the container was locked, and considering that there was a strong chemical smell, risk of fire could not be ruled out.

Figure 4 - Orange/ brown[45] smoke and acid leak as reported by the Master - *Source:* The Company (*annotation by TSIB*)

1.1.7.12 Subsequently, at about 1927H, the Operator's Singapore office communicated with the Colombo office to offload container *FSCU7712264* without further delay. In response, the Operator's Colombo office said that they would check

[45] When Nitric Acid reacts with metal, it produces heat, metal salts and oxides of nitrogen (i.e. Nitrogen Oxide and Nitrogen Dioxide). Nitrogen Dioxide is a brown gas.

the next morning with the Harbour Master's office and terminal for offloading of the container, as the office was closed for the day.

1.1.8 At Port of Colombo[46] – Anchorage

1.1.8.1 On 19 May 2021 at around 2348H, XP anchored at a location[47] about 9nm from the terminal, within port limits. XP awaited instructions for berthing, which was tentatively planned for six days later, i.e. 25 May 2021.

1.1.8.2 On 20 May 2021 at around 0045H, the EO left the ECR and returned to his cabin. The EO recalled being alerted by a fire alarm from his cabin's alarm panel. This was followed by a phone call from the duty Oiler informing him that a fire alarm[48] from cargo hold #2 had come on.

1.1.8.3 At about the same time, the CE was also alerted by the alarm from his cabin's alarm panel. The CE received a phone call from the OOW (A-2O) informing him that the Bridge's smoke detection and alarm system repeater panel[49] displaying a fire alarm coming from cargo hold #2.

1.1.8.4 The EO left his cabin and went to the Bridge[50]. At the Bridge, the EO recalled seeing the "FIRE" indication on the repeater panel which was sounding (and flashing), and he silenced it and left the Bridge to check the panel in the $CO_2$ Room.

1.1.8.5 On receiving the call from the A-2O, the CE took a round on deck in the vicinity of cargo hold #2 but did not see any abnormalities.

1.1.8.6 On the way down from the Bridge, the EO met the A-2E[51] at the staircase and together they proceeded to the $CO_2$ Room. The EO entered the $CO_2$ Room

[46] Tugs of 1,500-3,500hp range are available from the port authority. Port Fire Brigade is available on VHF Ch 14 and 16. Dangerous Cargo Declaration is to be forwarded to Safety Division 48 hours prior to arrival. Colombo Port Control must receive a copy endorsed by Safety Division 24 hours prior to ship's arrival. *Source*: IHS Maritime Ports & Terminals Guide 2017-2018. The relevant declaration was submitted by the appointed agents.
[47] Latitude: 16° 13' 4.79" N Longitude: 082° 13' 48.4" E as provided by the Port Authorities.
[48] All fire detection system data was lost with the ship. Due to the lack of data on which sensor inside cargo hold #2 was first activated, the investigation team could not establish the location where the smoke originated.
[49] According to XP's *Fire Control and Safety Plan,* there were three control panels for fire detection and alarm system – Bridge, ECR and FCS (on the Upper deck), and two control panels for the sample extraction smoke detection system.
[50] The muster list of XP could not be obtained by the investigation team. According to the muster list of the sister ship X-Press Mekong, the EO's role in a fire situation was to report to ECR, isolate power supply of the location of fire and adjacent place and follow the CE's orders.
[51] During discussions with the investigation team, the A-2E did not recall seeing EO at this time.

leaving the A-2E at the entrance. A while later, after several unsuccessful attempts to cancel the fire alarm (flashing yellow[52]), the EO exited the $CO_2$ Room but did not see the A-2E. According to the EO, the door to the E/R was ajar and the EO assumed that the A-2E had gone to the E/R to cancel the alarm, and the EO returned[53] to his cabin to rest.

1.1.8.7 During the interaction with the investigation team, the EO indicated that the condition of the electrical system onboard XP was normal and there was no indication of any earthing or insulation fault before the onset of the fire alarm. The EO also confirmed that the power supply for reefers inside cargo hold #2 had not been energised, in accordance with Company's requirements[54] as there was no reefer container being carried at the time.

1.1.8.8 Meanwhile, after his deck inspection for the source of the alarm, the CE went to the $CO_2$ Room and observed a flashing yellow light on the alarm panel. The CE reset the alarm and stayed in the $CO_2$ Room for about 10 minutes to monitor the alarm condition.

1.1.8.9 Satisfied with the alarm condition remained normal, the CE proceeded to the Bridge to confirm the status of the smoke detection and alarm system repeater panel. After few minutes of monitoring the status to be normal, before leaving the Bridge, the CE instructed the A-2O to call him and the Master immediately, should any fire alarm get activated again.

1.1.8.10 Around 40 minutes later, cargo hold #2[55] fire alarm again sounded from the Bridge's smoke detection and alarm system repeater panel. The A-2O informed the Master and the CE that the fire alarm for cargo hold #2 had activated again. The CE returned to the Bridge soon after.

1.1.8.11 The A-CO who was resting in his cabin, recalled being alerted by the fire alarm from his cabin's alarm panel and shortly after, also received a call from the Bridge informing him of the fire alarm from cargo hold #2.

1.1.8.12 When the A-CO arrived on the Bridge, he confirmed noticing the presence of

[52] According to the manual, this indicator will be activated and flashed when the system has detected an alarm condition.
[53] The EO has been working throughout the day and then follow-up with keeping the E/R watch during the approach to the anchorage. The EO did not inform the CE and the A-2E when he went to take rest.
[54] When not carrying reefer containers.
[55] The location was cargo hold #2 forward at bay 10 and the light was flashing red, indicating that there was a fire.

orange smoke coming from the direction of bay 11 on the starboard side. He further recalled the CE informing the Master (both on the Bridge) of his intention to inspect the passageway from the E/R to cargo hold #2 together with the A-2O. The Master then instructed the A-CO and duty ASD (ASD-1) to go on deck for a check of the situation.

1.1.8.13 The A-CO and ASD-1, while keeping clear of the smoke on deck, approached cargo hold #2 from the windward side (port side). The A-CO immediately reported to the Master when sighting smoke and heavy cargo leak from container *FSCU7712264*.

1.1.8.14 The Master instructed the A-CO to stay away from the smoke, to rig fire hoses and to commence boundary cooling on both port and starboard sides coamings of the cargo hold.

1.1.8.15 According to the A-CO, after boundary cooling continued for about two hours, the CE and the A-2O went inside cargo hold #2 to check the status and reported to the Master that there was no fire inside. The A-CO recalled that none of the officers and crew used SCBA sets during this period.

1.1.8.16 At about that time, according to the crew, the smell emanating from container *FSCU7712264* worsened (toxic fumes) and the Master was informed. The Master instructed the crew on deck to return and remain in the accommodation with all weathertight doors closed. The Master added, considering the extent of leak and smoke, he requested Colombo Port Control for an urgent and immediate berthing. Port Control in response, advised the Master to monitor the temperatures in cargo holds #1 to #3.

1.1.8.17 At about 0410H, when the A-CO returned to the Bridge to keep his navigational watch at anchor, he was told by the Master that a request for urgent berthing had been raised to Colombo Port Control, and that the agent and the Company had also been informed.

1.1.8.18 There was no instruction for the deck crew to monitor the condition of container *FSCU7712264* or the temperature of the cargo holds, although the watchkeeping ASDs had been instructed to carry out deck patrols. At about 0500H, the Master left the Bridge for his cabin to rest. The investigation team noted from the A-CO that the fire alarm from cargo hold #2 was still active

during his watch, though the audio alarm had been silenced, and that there was no confirmation for berthing from Colombo Port Control during his watch.

1.1.8.19 By about 0800H, the Master returned to the Bridge. The A-CO gave the daily job orders to the BSN for the deck crew to work near the accommodation and specifically instructed them not to go near cargo hold #2. Continuous fire and safety rounds were carried out by the watchkeeping ASDs, and the remaining crew were tasked to clean the accommodation air filters inside the Air-Conditioning Room located at the Upper deck.

1.1.8.20 The A-CO handed over the navigational watch to the 3O and left the Bridge soon after. According to the 3O, during taking over watch, thick yellowish-orange smoke was present in the vicinity of bay 11.

1.1.8.21 At about 1030H, during the CE's routine inspection rounds of the E/R, he noticed an unusual smell of burning rubber. Not seeing any abnormalities inside the E/R, the CE returned to the ECR and called the A-2E to accompany him to find out the source of the smell.

1.1.8.22 The CE and the A-2E entered the starboard side passageway and traced the smell to cargo hold #2. As both the CE and the A-2E entered cargo hold #2, they saw the space filled with smoke and several small fires at the top tiers between rows 05/07 and 06/08. One of these small fires was around the upper section door (along the rubber gasket) of one of the containers. In addition, the A-2E also recalled leak marks on some containers, as well as signs of melted metal (see **figure 5**).

Figure 5 - Leak marks on containers inside cargo hold #2 and burnt rubber as well as incandescent glow - *Source:* The Company (*annotation by the TSIB*)

1.1.8.23 The CE and the A-2E exited cargo hold #2 and while the CE waited at the passageway, the A-2E returned to the ECR and informed the Bridge of the fire in cargo hold #2. The A-2E then took a portable $CO_2$ fire extinguisher from the ECR and returned to cargo hold #2, where the CE was waiting[56].

1.1.8.24 Unable to extinguish the fire using the portable $CO_2$ fire extinguisher, the CE and A-2E left cargo hold #2, closed[57] the weathertight and watertight doors to the cargo hold and all the watertight doors along the passageway as they made their way back to the E/R. The CE reported to the Master and highlighted the need[58] to use the fixed $CO_2$ system to extinguish the fire inside cargo hold #2.

1.2 Discharge of $CO_2$ into cargo hold #2

1.2.1 After receiving the report (around noon) of fire inside cargo hold #2, the Master sounded the general emergency alarm[59]. The Master stopped all the ventilation fans for cargo hold #2 from the Bridge and instructed the 3O to announce over the PA in English and Mandarin, of the fire inside cargo hold #2 and for all the crew to muster at the secondary[60] muster station.

1.2.2 A few minutes later, except for the Bridge team comprising the Master, 3O and ASD-1, all twenty-two crew (including five off-signers[61]) mustered at the muster station. According to the muster list XP had five teams i.e. Bridge team, Special Duty team, Emergency team, Back-Up team and Support team.

1.2.3 At the instructions of the A-CO the Emergency team[62] brought two SCBA sets[63] and fireman suits. The A-CO updated the Master, who then instructed for all

[56] According to the SMS, a person seeing or smelling fire is required to raise the fire alarm, inform the Bridge of the location, attempt to extinguish the fire with a portable fire extinguisher if it is small, and isolate the space if the fire is large while waiting for assistance.
[57] The SMS recognised the importance of speed when tackling a fire, and also the prospect of containing a fire (minimising the damage) with quick closure of fans, dampers, fire doors, stairways etc.
[58] The SMS also stated that in the event of a serious fire, especially in the E/R or cargo spaces, which cannot be brought under control, the fixed firefighting system should be used.
[59] Seven or more short blasts followed by one long blast on ship's whistle and repeated on the emergency alarm bell.
[60] The primary muster station is at the boat deck, while the secondary muster station at the poop deck.
[61] Comprising the CO, 2O, 2E, 3E and MSM.
[62] Led by the A-CO comprising the BSN, ASD-2 and ASD-3.
[63] Two more SCBA sets available at the Fire Control Station on the Upper deck.

the ventilation flaps for cargo hold #2 to be shut and for the CE to prepare the fixed $CO_2$ system for discharge.

1.2.4 The A-CO then assigned the A-2O[64] to take the BSN, OS-1, and OS-2 to close the natural[65] ventilation flaps on the starboard side and all the mechanical ventilation flaps for cargo hold #2.

1.2.5 Concurrently, while the SCBA sets were being prepared the crew noted air was escaping from the mask and mistook that as a leak[66] and kept the SCBA at the side. The A-CO then instructed the ASD-2 and ASD-3 to close the natural ventilation flaps on the port side, while some crew members went to rig hoses for boundary cooling at cargo hold #2.

1.2.6 The two OS went to the starboard side main deck passageway and proceeded to close the natural ventilation flaps. However, due to smoke and heat, they could not close some of the natural ventilation flaps on the starboard side (mainly at bay 11). Accordingly, the two OS[67] returned aft to the poop deck.

1.2.7 The A-CO arriving at bay 11 on the port side saw that the whole deck and lashing bridge from the centreline towards the starboard side were covered with light grey smoke. There was no sign of fire on deck.

1.2.8 At that time, the A-2O received a report from the BSN, that all the mechanical ventilation flaps for cargo hold #2 had been closed, which was reported to the A-CO. During the interaction with the investigation team, the A-2O shared that he was not aware that some of the natural ventilation flaps in-way of bay 11 starboard side remained opened as he did not receive any report from the two OS of any difficulty closing the flaps.

1.2.9 A few minutes later, the ASD-2 and ASD-3 reported to the A-CO that all natural ventilation flaps on the port side were closed, who updated the Master accordingly. Thereafter the duo joined several other crew members to rig hoses

[64] Leader of Support team comprising the OS-1, OS-2, Cook and Messman.
[65] Total 36 natural ventilation flaps for cargo hold #2, with 18 located on either side of the hatch cover panel, and 20 mechanical ventilation flaps at cross deck.
[66] Compressed air escape if the positive pressure mode on the mask is selected and valve of the cylinder is open.
[67] The two OS did not specifically inform any crew, just a general statement or remarks that some of the natural ventilation flaps could not be closed due to heat and smoke.

for boundary cooling at cargo hold #2.

1.2.10 The Master, after discussing with the CE on the need to use the fixed $CO_2$ system to extinguish the fire inside cargo hold #2, instructed the A-CO and all crew to return to the poop deck.

1.2.11 During the interaction with the investigation team, when asked to elaborate the difficulty encountered during firefighting, the A-CO replied that none of the crew had donned the fireman's outfit and/ or the SCBA sets. The A-CO added that the fireman's outfit and the SCBA sets had been collected and placed near the port side gangway area.

1.2.12 Meanwhile, the CE went down to the $CO_2$ Room via the poop deck to prepare the fixed $CO_2$ system for discharge. According to the A-2E, he was asked by the CE to go to the $CO_2$ Room with him and since the A-2O was supervising the closing of ventilation flaps and rigging of fire hoses for boundary cooling, the A-2E did not leave any instructions to the crew of the Back-Up team[68] and followed the CE to the $CO_2$ Room. The EO, upon hearing that the CE and A-2E were heading to the $CO_2$ Room, followed both down to the $CO_2$ Room.

1.2.13 While the CE and A-2E were preparing the fixed $CO_2$ system for discharge, the EO broke the glass of the $CO_2$ release cabinet[69] and handed the key to the CE. Subsequently, the EO exited and waited outside the $CO_2$ Room for instructions.

1.2.14 Meanwhile, after receiving the status of the ventilation flaps for cargo hold #2, the Master instructed the A-CO to carry out another headcount. After few minutes, the A-CO reported that all crew[70] including the off-signers were accounted for. The Master gave the order for the CE to release the $CO_2$ into cargo hold #2.

1.2.15 The A-2E added that together, he and the CE opened the pilot bottle and

[68] Led by the A-2E comprising the Fitter, Oiler-1, Oiler-2 and Wiper.
[69] Opening of the release cabinet sounds the $CO_2$ alarm for the cargo hold at all the visual and audio alarm indicators located outside the $CO_2$ Room, Bridge, ECR, E/R and along both Under-deck passages.
[70] Except for the Bridge team, the C/E, A-2E, EO and 3E at their respective stations, all the other crew were accounted for at the muster station.

activated the levers of the pilot cylinder valve, no.1 main valve and no.2[71] discharge valve (see **figure 32**) for the release of $CO_2$ into cargo hold #2. The CE and A-2E verified that $CO_2$ was released by looking at the pressure gauge and noting frosting on the pipelines.

1.2.16 During the interaction with the investigation team, the A-2E recalled that as per the $CO_2$ operating instructions, there were 170 bottles available for release into cargo hold #2. To the investigation team's question on whether the quantity of $CO_2$ released into cargo hold #2 was proportional to the volume of cargo inside, the A-2E responded that they just activated the levers, and he was not aware of the cargo volume in cargo hold #2. According to the CE and A-2E, there was no instruction or discussion on the number of bottles to be discharged in relation to the volume of the cargo inside the cargo hold.

1.2.17 After $CO_2$ was released, the Master instructed the A-CO to organise the crew for boundary cooling and monitor the temperature[72] of cargo hold #2. Subsequently, water was sprayed on the containers along the main deck, hatch cover top and coamings in the vicinity of cargo hold #2.

1.2.18 About an hour after the release of $CO_2$, the A-2E returned to the $CO_2$ Room and confirmed that pressure gauges of the $CO_2$ bottles were showing zero, the pins on top of the bottles had come off, indicating that $CO_2$ had been released.

1.2.19 According to the Master, boundary cooling was subsequently suspended, and the crew (including the off-signers[73]) were told to return to the poop deck. To further prevent the temperature of cargo hold #2 from rising, ballast tanks adjacent to cargo hold #2 were also filled up.

1.2.20 Situation after the release of $CO_2$ - 20 May 2021

1.2.21 At about 1406H, black smoke was observed coming out from cargo hold #2, the Master immediately reported to Colombo Port Control that XP had discharged all the fixed $CO_2$ into cargo hold #2, black smoke was coming out

[71] The A-2E recalled that there were four "levers" for the release of $CO_2$ into cargo hold #2. The investigation team gathered that one lever was for the main valve, the other three levers control three other valves which corresponded to the number of $CO_2$ bottles to be released into a cargo hold. See **table 7** for details on the quantity of $CO_2$ to be released corresponding to the cargo volume in the respective cargo holds.
[72] The A-CO assigned the A-2O to monitor the surface temperature (using the infra-red thermometer).
[73] The off-signers were standing-by at the ship's office waiting for instructions.

from cargo hold #2, and requested for shore assistance.

1.2.21.1 At about the same time, the A-2O reported to the Bridge that the surface temperature of cargo hold #2 was steadily rising, with the coamings and hatch covers' reading between 81˚C and 85˚C, and occasionally rising to 90˚C. The Master then instructed the crew (except the off-signers[74]) to resume boundary cooling along the hatch covers, coamings, and deck containers.

1.2.21.2 The A-2E, ASD-1 and ASD-3 went to check cargo hold #2 for signs of re-ignition. The A-2E reported to the Master that cargo hold #2 was full of smoke, but no fire was sighted. Neither of them wore the SCBA sets.

1.2.21.3 At about 1530H, a Sri Lankan Navy ship came alongside XP. The boundary cooling was again suspended, and the crew were asked to stand down as four personnel comprising three firemen and one naval officer boarded XP to inspect the situation[75] in cargo hold #2.

1.2.21.4 At the request of the firemen, the A-2E asked the A-CO for the chemical suits to be brought to the site. In addition, XP's SCBA sets were also brought to the location together with the MSDS of the cargo. The A-2E recalled that the firemen did not don XP's chemical suits but wore their own SCBA sets and inspected the site from the cross deck at bay 11. See **figures 6 and 7** indicating orange/ brown smoke at the vicinity of cargo hold #2 and increasing in intensity, respectively.


Figure 6 - Orange/ brown smoke - *Source:* Screenshot from Exclusive Video footage posted by newsfirst.lk

[74] The investigation team could not establish the reasons for not utilising the off-signers.
[75] Prior to the inspection, the shore personnel went to the Bridge for an oversight of XP's deck cargo.


Figure 7 - Orange/ brown smoke increasing in intensity - *Source:* Screenshot from Exclusive Video footage posted by newsfirst.lk

1.2.21.5 The firemen informed the A-2E that due to presence of chemical fumes and $CO_2$ in cargo hold #2, they would have to return to port and discuss further actions. All the four personnel disembarked XP at about 1830H. The investigation team noted from the video footage that the surface temperature of cargo hold #2 was about 80°C (see **figure 8**).


Figure 8 - Temperature of cargo hold # 2 - *Source:* Screenshot from Exclusive video footage posted by Newsfirst.lk

1.2.21.6 After about 1.5H had passed, without any updates since the Sri Lankan Navy ship left XP, the Master called Colombo Port Control for the next course of action and was advised to keep monitoring the temperature of cargo hold #2. At that time the temperature readings of cargo hold #2[76] were 60°C (port side) and 95°C (starboard side). See **figure 13** - for the temperature of the cargo hold).

1.2.21.7 Subsequently at about 2011H, the Master again reportedly[77] called Colombo

[76] Temperatures as recorded in the Master's report.
[77] The investigation team could not corroborate this communication due to the lack of VDR data.

Port Control informing them of the temperatures of cargo hold #2. That same night, the A-CO instructed the BSN and the two OS to keep an additional fire and safety watch[78] along with the deck officers and ASDs. The investigation team noted that boundary cooling was not resumed after the four shore personnel disembarked XP. Reasons for this could not be established.

1.2.21.8 At around 2300H, the Master who was with the 3O on the Bridge recalled seeing a flame along with thick smoke that was higher than the stack of containers in the region of position 110582 (see **figure 9**).

Figure 9 - Photo taken at about two hours after fire was sighted - *Source:* The Company

1.2.21.9 The general emergency alarm was again sounded, followed by a PA announcement of a container fire at bay 11.

1.2.21.10 The Master called Colombo Port Control and requested shore tugs' assistance for firefighting. At the same time, the Master again reminded Colombo Port

[78] Additional lookouts on the Bridge as follows:

- OS-1 – 0001-0400H and 1200-1600H with A-2O and ASD-1
- BSN – 0400-0800H and 1600-2000H with A-CO and ASD-3
- OS-2 – 0800-1200H and 2000-2400H with 3O and ASD-2

Control that $CO_2$ on XP had been totally released into cargo hold #2.

1.2.21.11 The Master then instructed the crew to commence firefighting and at the same time to resume boundary cooling of hatch covers, coamings, and containers in the vicinity of cargo hold #2. On being asked, the Master confirmed that all the power supply (particularly electricity supply meant for reefer containers on deck) at bays 10 and 14 had been isolated.

1.2.21.12 The ship's crew fought the fire by directing water jets from the port and starboard sides, and from the cross deck towards the containers on fire. After spraying water from the starboard side for about 45 minutes, noting the starboard side was full of smoke, the A-2E donned a fireman's outfit (without the SCBA sets) near the accommodation and went to the port side in way of bay 10 cross deck and started spraying water towards the starboard side (see **figure 10**[79]).

Figure 10 - Firefighting efforts by the crew - *Source:* The Company

1.2.21.13 The A-2E informed the investigation team that this location (port side cross deck of bay 9) was about five metres away from the containers on fire and the crew used a combination of water jet and fog curtain mode to fight the fire. During this time, the A-CO was constantly providing guidance to the firefighting team.

1.2.21.14 On the investigation team's query of the challenges experienced in fighting the fire while not donning the SCBA sets and the fireman's outfit, both the A-2E

[79] Images of crew firefighting / boundary cooling operation from bay 09, on the port side of XP centerline.

and A-CO mentioned that the intensity of the chemical smoke[80] made it difficult to stay in location for long. Like the A-CO, the A-2E too, could not explain why the SCBA sets were not donned.

1.3 Firefighting with shore assistance

1.3.1 Day one[81] – 21 May 2021

1.3.1.1 At about 0120H, the first firefighting tug[82] "Megha" from Colombo Port Control arrived for firefighting. The Master instructed "Megha" to direct its firefighting effort on the containers at bay 10, rows 05/07 and tiers 88/90 that were on fire. Shortly after, "Megha" began directing jet of water on the burning containers, XP's crew stopped[83] firefighting operation and returned to the poop deck. At that time, the A-2E recalled that when he was returning aft to the poop deck, fumes from cargo hold #2 had increased.

1.3.1.2 The Master recounted that the firefighting capability of "Megha" was ineffective as the water directed from the tug could barely reach the containers on fire. The Master instructed the crew to resume firefighting and reported the situation to Colombo Port Control. According to the A-CO, seven fire hoses[84] (three on the port side and four on the starboard side) were used for firefighting and boundary cooling.

1.3.1.3 By about daybreak, two more tugs "Hercules" and "Maha Wewa" from Colombo Port Control arrived for firefighting. With the firefighting capability increased by the two tugs (see **figure 11**), the Master instructed XP's crew to return to the poop deck again. In his interaction with the investigation team, the Master commended the ability of "Hercules" in firefighting as the water

[80] Orange smoke seen along the deck level of cargo hold #2 and grey smoke from the top container tier on bay 11.
[81] The Company's signed the Lloyd's Open Form (LOF) with SMIT salvage. The LOF allows parties to reach a swift agreement on contractual terms when a ship is in distress. It is designed to suit emergency situations, as it saves precious time from negotiations thus protecting the crew, property, and the environment. Salvage services performed pursuant to LOF are deemed as a pure salvage and not contract salvage because the salvor is engaged on a "no cure – no pay" basis and the reward amount is open until the amount of success. *Source*: www.gard.no. SMIT Salvage were the salvors appointed by the Company.
[82] Refer to **Appendix 4** for details of tugs assisting in the firefighting.
[83] The Master was concerned for safety of his crew on deck when firefighting tugs are involved.
[84] Two forward manned by the BSN, one ASD and one OS, two aft manned by two ASDs and the other OS, two downwind manned by the Oiler and A-2O. One hose was tied to the railing on deck.

outreach and manoeuvrability of the tug was effective.

Figure 11 - Tug Hercules in the vicinity of XP - *Source:* www.hirunews.lk (left), Sri Lankan Navy (right)

1.3.1.4 The Master informed the investigation team that "Hercules" was, however called back to assist in ship movements in port, after having assisted in firefighting for about six hours. The Master called Colombo Port Control a few times requesting for tug "Hercules" to return to assist XP in firefighting but did not receive any response[85].

1.3.1.5 Later during the day, the Sri Lankan Air Force deployed[86] a Bell-212 helicopter for firefighting by dropping bags of DCP (see **figure 12**) onto the burning containers, primarily rows 05 and 07 (tier 88/90). The number of bags dropped onto XP were not known to the investigation team and the effectiveness of those that landed.

Figure 12 - Bags of DCP being dropped on XP - *Source:* www.hirunews.lk

[85] XP's crew resumed boundary cooling during those periods.
[86] *Source*: Colombo Page News Desk, Sri Lanka, 21 May 2021, 9:26pm Sri Lankan time.

1.3.1.6 At about 2015H, while XP's crew and "Maha Wewa" were carrying out boundary cooling at the vicinity of cargo hold #2, an explosion was heard and containers on deck in-way of bay 10 were seen to be on fire.

1.3.1.7 By this time, "Hercules" had returned for firefighting. With two tugs shooting water on the burning deck of containers, the Master called the XP's crew[87] to stand-by inside the accommodation. For the next few hours, "Maha Wewa" (starboard side[88]) and "Hercules" (port side) continued spraying water towards cargo hold #2 in-way of bays 10 and 14.

1.3.1.8 The investigation team collated the temperatures recorded by the crew[89] of XP (over a period of two days) which are collated in **figure 13**.

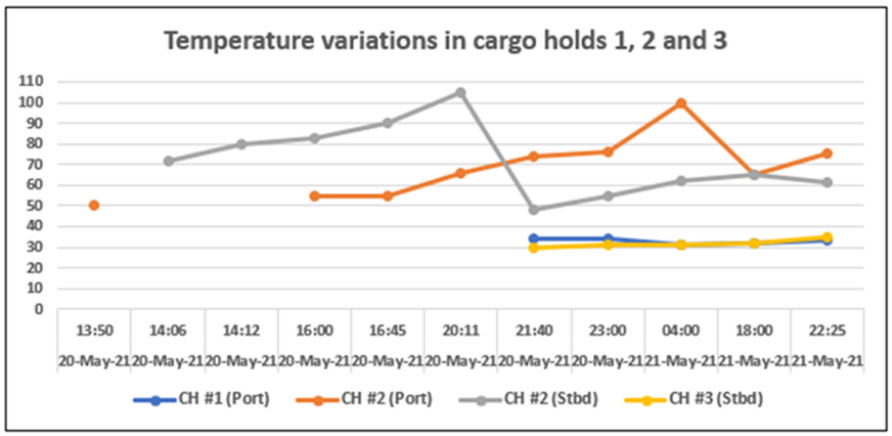



Figure 13 - Temperature readings collated by TSIB - *Source:* The Master of XP

1.3.2 Day two – 22 May 2021

1.3.2.1 According to the Master, firefighting operation was carried out by "Maha Wewa" and "Hercules" through the night. At about 0240H, an explosion was heard from inside cargo hold #2.

1.3.2.2 At about 0400H, "Hercules" took up "Maha Wewa's" position on XP's starboard side and continued spraying water towards cargo hold #2, while the latter returned to port. The Master, seeing only "Hercules" was conducting

[87] Excluding the off-signers as they were already inside the accommodation.
[88] Reference made to starboard side of XP.
[89] According to the A-CO, there was no specific person monitoring the temperature of the cargo holds regularly.

firefighting, called Colombo Port Control requesting more tugs for firefighting. About 15 minutes later, “Maha Wewa” returned to XP, took up position on XP’s port side and resumed spraying water towards cargo hold #2.

1.3.2.3 By about daybreak, few more tugs[90] arrived and provided firefighting assistance to XP. The investigation team sighted exchange of messages between the Master and the Company that the off-signers were not willing to assist in the firefighting efforts any longer. According to the Company, the off-signers held the view that they had handed over the duties to the new crew and thus their responsibilities were over.

1.3.2.4 At around 1820H, “Maha Wewa” ceased spraying water. “Maha Wewa” was connected to XP and began to pull XP’s stern to the wind for an effective firefighting operation.

1.3.2.5 During the day, several tugs were noted spraying water continuously towards the fire and smoke at cargo hold #2 in-way of bays 10 and 14.

1.3.3 Day three – 23 May 2021

1.3.3.1 The Master and A-CO were on the Bridge on six-hourly rotation to manage the firefighting efforts. At about half hour past midnight an explosion was heard[91] on deck, in-way of bay 10 which was followed by another explosion at about 0330H between bays 10 and 14. At about 0500H, tug “Posh Teal” moved out from XP’s location to meet tug “Yaanik” to pick up the salvors.

1.3.3.2 At about 0530H, the 12-man salvors team, comprising a Salvage Master, Naval Architect, Firefighters, Marine Chemist amongst others were transferred from “Yaanik” to “Posh Teal”. At about 0600H, at the instructions of the salvors, “Hercules” came to the port side to direct a straight stream of water to cargo hold #3 to avoid the spread of fire aft towards the accommodation.

1.3.3.3 Tug “Posh Teal” resumed firefighting at about 0650H at the advice of the Salvage Master, who also instructed “Maha Wewa” to adjust its position to pull XP’s stern to the wind (to prevent heat and smoke from spreading to cargo

[90] Tugs “Hercules” (starboard side), “Maha Wewa”, “Megha”, “Posh Hardy” and later joined by “Posh Teal” (port side).
[91] According to the Master of Posh Teal.

hold #3 and the accommodation).

1.3.3.4 At about 0900H “Prantik Sarwar” relieved “Hercules” for the latter to return to port for bunkers.

1.3.3.5 At about 1050H, “Hercules” returned to XP and resumed firefighting. Following that, both tugs “Prantik Sarwar” and “Maha Wewa” were connected and began to pull XP’s stern to the wind. At about 1100H, a safety toolbox meeting was conducted using radio communication between the salvors and XP’s Master on ways to fight the fire.

1.3.3.6 Later in the day, at about 1330H, the 12 salvors were transferred to “Yaanik” to be sent onboard XP while “Posh Teal” remained in position for firefighting. To meet the LSA capacity of XP, 12 crew members from XP were transferred to “Posh Teal” [92].

1.3.3.7 The team of salvors continued to provide instructions for firefighting operation. Temperature of cargo hold #2 was taken and measured to be 70˚C and a fire monitor was placed by the salvors on the hatch cover to cool bay 9.

1.3.3.8 At about 1450H, “Prantik Sarwar” reported machinery problems and her crew cut the towline for the tug’s safety. On completion of transferring personnel and equipment, “Posh Teal” assisted “Maha Wewa” (that remained connected to XP) to pull XP’s stern to the wind, as instructed by the salvors.

1.3.3.9 Subsequently, tug “Aries” arrived and joined “Hercules”, “Megha”, “Posh Hardy” in firefighting operation.

1.3.3.10 At about 1500H, the salvors added another fire monitor on the port side and adjusted the fire monitor at the starboard side, at bay 09. According to the salvors large amounts of steam was observed coming from the hatch cover.

1.3.4 Day four – 24 May 2021

1.3.4.1 At about 0130H, a fire alarm from the Upper deck sounded. An inspection carried out within the accommodation by XP’s crew and the salvors

[92] The 12 crew members were subsequently landed ashore on 24 May 2021.

confirmed[93] no sign of fire. At about that time, “Maha Wewa” was disconnected from XP’s starboard quarter.

1.3.4.2 Continuous firefighting was carried out through the night by the salvors and assisted by several tugs taking turns (for servicing and maintenance). At the instructions of the salvors, XP’s mooring ropes were connected to “Posh Teal” by about 0500H.

1.3.4.3 By about 0700H, the weather started to deteriorate[94]. From 0730H to 1000H, the salvors (comprising four Firefighters and one Chemist) were escorted by the CE and A-2E, through the underdeck passage, towards the cargo holds #1, #2 and #3 where the salvors carried out an inspection.

1.3.4.4 The team using an infra-red thermometer and a gas detector, noted that the port passageway (temperature recorded as 96˚C) indicated presence of toxic gases, while the starboard passageway (temperature recorded as 85˚C) indicated presence of both toxic and explosive gases. No water was seen inside cargo hold #3 and the temperature within was recorded as 45˚C. The salvors further noted that the fire was concentrated inside cargo hold #2 (upper section), and on deck above the hold.

1.3.4.5 Around 1050H, when the swell was observed by the crew of Posh Teal to be about 3.5m, the mooring line connecting XP to “Posh Teal” parted, and “Posh Teal” began preparing its steel tow wire for re-connecting to XP.

1.3.4.6 The salvors noting the four hours’ time taken for “Posh Teal” to be reconnected to XP, called tug “Astro Capella” with an ETA at about 1430H, to connect to XP replacing tug “Posh Teal”. Thereafter, “Posh Teal” was instructed to position itself on XP’s starboard side for firefighting operation (see **figure 14**).

[93] According to the salvors, the fire alarm was likely triggered by smoke blown by wind from cargo hold #2 towards the accommodation.
[94] Wind force BF 7 (28 to 33 knots).


Figure 14 - Tug “Posh Teal” spraying water from XP’s starboard side – *Source:* gCaptain as obtained from SLPA

1.3.4.7 Meanwhile, as a safety precaution to prevent accumulation of fumes in the E/R, fresh air intake flaps were shut, air-conditioning filters for fans to the E/R were cleaned, all supply fans to the E/R were stopped, the E/R air-conditioning was placed on re-circulation and only one exhaust fan was kept running. The A-2E recalled that there were no abnormalities in the E/R at this time.

1.3.4.8 At about 1445H, “Astro Capella” arrived and was connected to XP’s aft centreline lead using the mooring rope. At the same time, due to strong wind and rough seas, in consultation with the salvors, to mitigate the risk of XP dragging anchor towards shallow waters, XP’s anchor chain was lowered to about nine shackles in the water. Tug “Astro Capella” was directed by the salvors to pull on XP’s starboard quarter while maintaining a heading of 270°True (westerly).

1.3.4.9 Between 1715H and 1800H, “Astro Capella’s” mooring rope was transferred to XP’s starboard quarter. At about 1810H, according to witness accounts, there was an explosion at bay 10 causing XP to shake and vibrate. “Posh Teal” was instructed to relieve “Astro Capella” at XP’s centreline lead using the tug’s wire rope and thereafter, to maintain a heading of 270°True (westerly).

1.3.4.10 Around 1845H, the salvors who inspected cargo hold #1 reported that water had entered the hold and the water level had reached the top of the lowest tier containers.

1.3.4.11 Around 1910H, “Hercules” departed, while “Astro Capella” and “Aries” resumed firefighting. At about 1930H, a large fire was noted at the top

container of bay 11. According to witness accounts, another explosion was heard around 30 to 40 minutes later.

1.3.4.12 Around 2100H, four containers from the starboard side fell into the sea. The Master reportedly requested Colombo Port Control via VHF for immediate berthing but did not receive any response.

1.3.4.13 Around 2110H, “Aries” stopped firefighting due to problems with its fire pump. Between 2130H and 2200H, “Posh Hardy” which had returned earlier at an unknown time, reported difficulties with its fire pump.

1.3.4.14 From 2200H to 2300H, “Astro Capella” and “Posh Hardy” alternated their positions in firefighting on both port and starboard side of XP. At 2305H, “Hercules” returned to XP’s starboard side to assist in firefighting.

1.3.5 Day five – 25 May 2021

1.3.5.1 By about 0100H, the wind which was about 25 knots had reduced below 20 knots, with seas becoming slight from moderate. Around 0115H, the Master noted that XP’s starboard gangway and winch on the Upper deck (near the accommodation) were damaged due to “Posh Teal” pulling on the steel wire connected at XP’s centreline lead on the Upper deck.

1.3.5.2 At around 0200H, “Hercules” was on XP’s starboard side, while “Posh Hardy” and “Aries” continued to fight fire from the port side. About 30 minutes later, “Astro Capella” requested for relief and was replaced by “Posh Hardy”.

1.3.5.3 Then at about 0335H the weather condition deteriorated further, with the wind increasing to about 30 knots, with frequent gusting to 35 knots, causing the tow wire from “Posh Teal” to part. XP began to drag anchor towards the shoreline at an approximate rate of 1.3 to 1.5kts.

1.3.5.4 At about 0420H, after “Posh Teal” had recovered its tow wire, the tug began its operation to re-attach another tow wire for XP. Meanwhile, the Master of XP used the main engine intermittently to reduce XP’s drag while maintaining its orientation in keeping the wind on its beam (keeping the smoke away from the accommodation).

1.3.5.5 According to the salvors, the Master called Colombo Port Control via VHF

requesting for XP to proceed to a sheltered area inside the port as the weather condition had worsened and that the ship was dragging anchor. Colombo Port Control's response was that they would look into the request. Efforts by the salvors to call the Harbour Master twice using the phones were unsuccessful as the calls were not answered.

1.3.5.6 Between 0400H and 0500H, another explosion[95] was heard, and this time, the CE noted that the E/R skylight and watertight doors leading to the E/R from the underdeck passage had been damaged due to the explosion and were unable to be closed. The CE further recalled that there was lot of smoke in the E/R with strong smell of ammonia and advised the Master against the use of the main engine. Subsequently, the engineers evacuated the E/R as flames and smoke were seen spreading towards the aft of XP.

1.3.5.7 The Master noting the accommodation area engulfed in smoke made a PA announcement (between 0435H[96] and 0505H[97]) to abandon ship. The A-CO activated the distress button on the VHF and alerted the Sri Lankan Navy and Colombo Port Control regarding the explosion and fire in the E/R.

1.3.5.8 During this time, the Salvage Master called for "Yaanik" to assist the evacuation of personnel on XP's port side, but "Yaanik" was unable to pick up XP's personnel due to the prevailing sea state (swell was about 3 to 5m) and fumes. A similar request was made to "Posh Teal" which was also unsuccessful.

1.3.5.9 All personnel onboard XP had by then mustered at the poop deck. According to the Master after the initial plan to abandon ship via the gangway was not possible, he instructed the crew to prepare the freefall lifeboat. Due to accumulation of thick smoke with strong chemical smell (irritating the eyes) around the accommodation, the freefall lifeboat deck was inaccessible to the crew.

1.3.5.10 Considering the weather, the Master decided that it would be safer for the crew

[95] Witness accounts indicated that the first explosion from the E/R was heard at about 0400H. According to the Master, the E/R explosion was heard at 0500H which was followed by a phone call from the 3E informing the Master to stop the main engine as there was too much smoke inside the E/R.
[96] Salvor's account.
[97] XP Master's account.

to disembark from XP's stern. The crew then prepared mooring ropes secured to the bollard on deck, with its loose end hanging to the water level.

1.3.5.11 According to the Master, at about 0540H, an explosion[98] was heard again, this time from the E/R followed by another explosion about 10 minutes later which resulted in some of the persons to be covered in debris. At about 0545H, in a gale force wind of about 35 knots with swell of about 3 to 5m, near zero visibility due to smoke and heavy rain, "Hercules" approached with its bow towards XP's stern. The loose end of the mooring rope was taken onboard the tug to facilitate the crew to climb down together with their documents and personal belongings using the ropes.

1.3.5.12 During this descent, the A-CO and A-3E sustained injuries[99]. After XP was abandoned (the CE and Master were the last ones to leave), "Hercules" pulled away from the burning XP with 25[100] persons.

1.3.5.13 See **figure 15** dated 25 May 2021 – Fire condition of XP after being abandoned.

Figure 15 - XP after being abandoned - *Source:* SLPA

1.3.5.14 See **figure 16** depicting XP continued to burn over the next few days.

[98] According to the salvors, the second explosion was reportedly heard just before 0500H.
[99] Both the A-CO and 3E sustained injuries to the leg as they jumped while descending from XP to tug "Hercules".
[100] 13 ship's crew and 12 salvors.

Figure 16 - Fire spread to other parts - *Source:* SLPA and Indian Coast Guard (ICG) respectively

1.3.5.15 See **figure 17** on photos taken on 1 June 2021.

Figure 17 - Salvors onboard XP to inspect the extent of damage - *Source:* SLPA (*annotation by TSIB*)

1.3.5.16 See **figure 18** on photos taken on 3 June 2021.

Figure 18 - XP sitting on the shallow seabed - *Source:* The Company and Sri Lankan Air Force

1.3.6 Capabilities of the tugs

1.3.6.1 In addition to the tugs being used for port operations halfway during the firefighting operation, the following challenges were observed by the Master and the salvors dealing with some of the tugs involved in the firefighting operation:

- Difficulty in positioning of the tugs for firefighting;
- The tugs not being able to provide sufficient water pressure to reach the top of the containers or even onto the main deck; and
- The tugs having engine/ machinery problems that required repairs, thus, causing a break in firefighting efforts.

1.3.7 Assistance by the Indian Authority

1.3.7.1 At the request of the SLPA, the ICG deployed ICG ships Vaibhav[101] and Vajra[102] for firefighting operation, ICG ship Samudra Prahari was on stand-by for pollution response, and ICG aircraft Donier performed air reconnaissance

[101] ICG Vaibhav arrived at scene on the 25 May 2021.
[102] ICG Vajra arrived at scene on the 26 May 2021.

for pollution detection.

1.4 Design of XP

1.4.1 XP's design, construction requirement for structure, subdivision and stability, machinery, and electrical installations were as per SOLAS, 1974, as amended. The accommodation block consisted of the Upper deck as the main deck and six other decks from 'A' to 'F', then the navigation Bridge and the Compass deck. Below the Upper deck, the 2nd deck held a passageway which allows access to the cargo hold spaces from the E/R to the forward of XP. See **figure 19** – showing the profile view of XP.

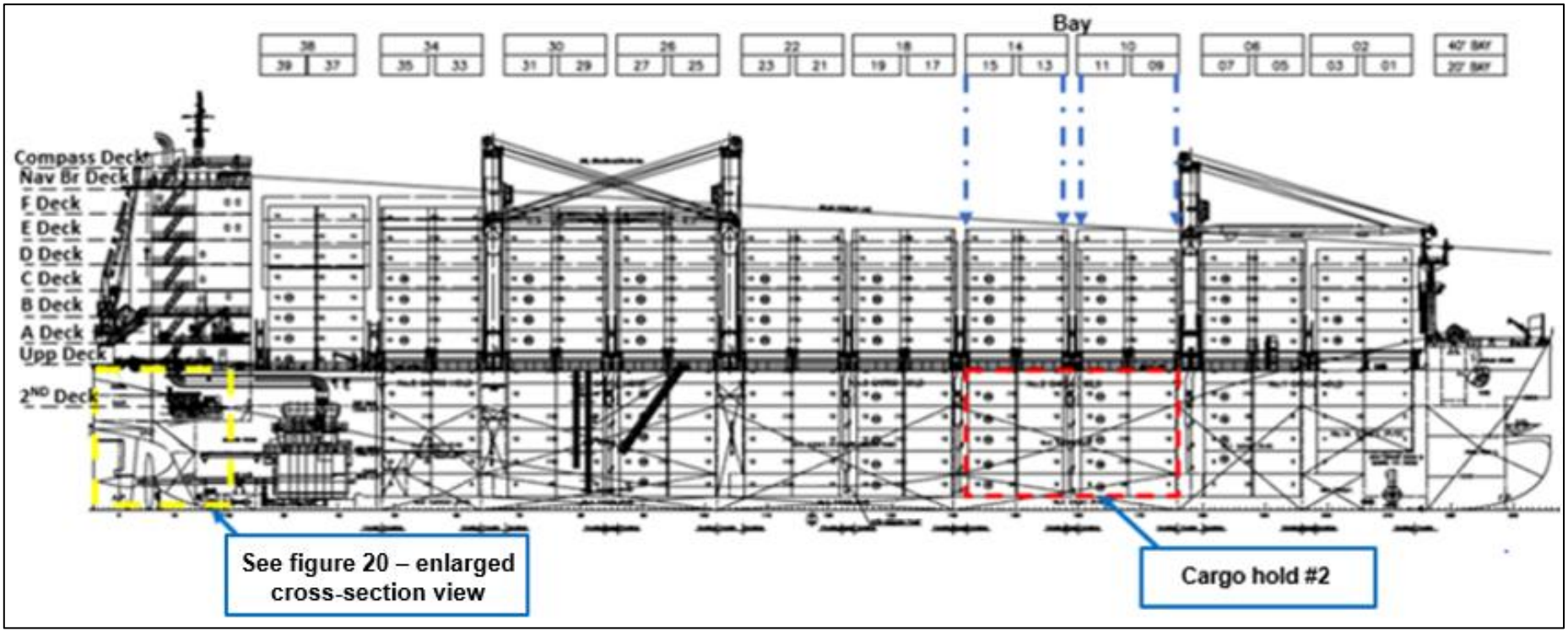



Figure 19 - Starboard side profile view of XP – *Source:* The Company (*annotations by TSIB*)

1.4.2 The $CO_2$ Room was located aft of XP's accommodation block, below the Upper deck. Entrance to the $CO_2$ Room via a staircase from the poop deck (see **figure 20**).

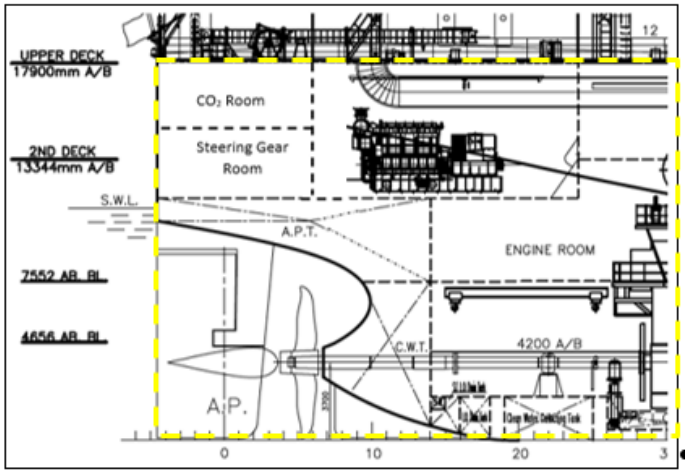



Figure 20 – Location of the $CO_2$ Room - *Source:* The Company (*annotations by TSIB*)

1.4.3 Arrangement of cargo holds

1.4.3.1 XP had five cargo holds ranging in volume from 6,000$m^3$ (cargo hold #5 – smallest) to 14,640$m^3$ (cargo hold #3 – largest). Cargo hold #2 was about 14,250$m^3$. The bays for cargo hold #2 are depicted in **figure 21**.

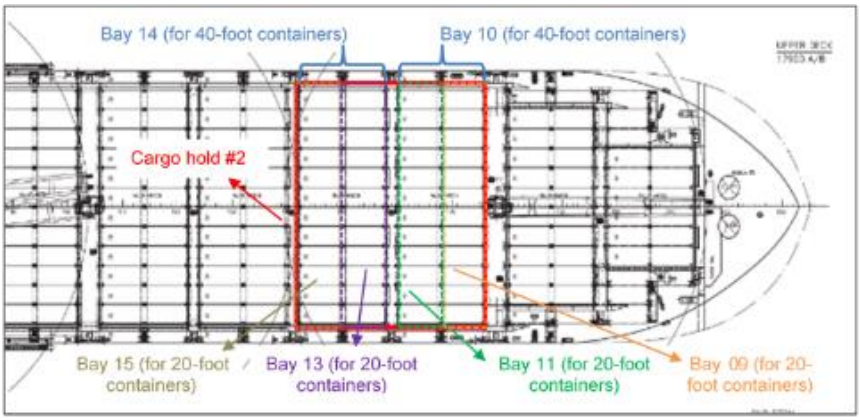



Figure 21 - Plan view of cargo hold #2 upper deck – *Source:* The Company (*annotations by TSIB*)

1.4.3.2 All the cargo holds were designed to carry DG as specified by the Class approved Document of Compliance “Special Requirement for Ships Carrying Dangerous Goods”.

1.4.4 Arrangement of hatch cover panels

1.4.4.1 The cargo holds were fitted with non-weather tight hatch cover[103] panels, typical for a ship of this design (see **figure 22**).

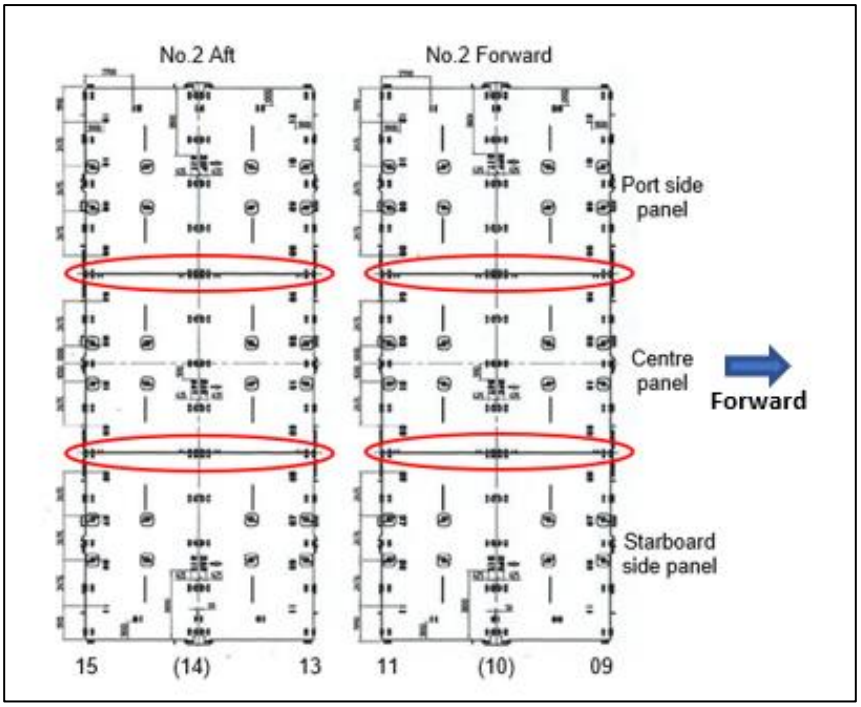



Figure 22 - Hatch cover panels of cargo hold #2 (forward and aft) showing the gaps between the fore-aft gutter plates (circled in red) - *Source*: The Company (*annotations by TSIB*)

1.4.4.2 These panels had gaps[104] of about 30 +/- 10mm between the fore-aft gutter plates shown in **figure 23**, an industry standard widely used on container ships to ease handling (removal in a non-sequential manner) of panels for access to containers in cargo hold, approved by the Classification Society. The gap was

[103] There were three hatch cover panels per bay (port, centre and starboard).
[104] Besides, for ease of closing/ opening the panels, it was also meant to displace air in the cargo hold when $CO_2$ is released.

also to ensure that natural air would escape the cargo hold in case of $CO_2$ release (to minimise overpressure in the cargo hold) and to ensure that the cargo hold was saturated with $CO_2$ (being heavier than air).

Plan view of the 40mm gap between the fore and aft gutter plates

Plan view of the gaps at the aft end of the hatch cover panel

Figure 23 - Gaps between the hatch cover panels - *Source:* The Company

1.4.4.3 The design requirements for coaming height and hatch covers followed the International Association of Classification Societies (IACS) Unified Interpretation (UI) of Load Line 1966 (LL66) and obtained the approval of the flag Administration[105] in accordance with Regulations 2(5)123 and 14(2)124 of the Load Line Convention.

1.4.5 Ventilation system of cargo holds

1.4.5.1 All cargo holds were provided with supply fans as per **table 5** below, located along the cross deck at the under-deck passage level (entrance to the cargo hold).

[105] Flag Administration's condition for approval among others, includes:
- "…limited to use on container ships"
- "…hatchway coamings should be not less than 600mm in height"
- "…non-weather tight gaps between hatch cover panels should be considered as unprotected openings with respect to the requirements of intact and damage stability calculations. They should be as small as possible and commensurate with the capacity of the bilge system and expected water ingress, and the capacity and operational effectiveness of the firefighting system and, generally, should not exceed 50mm" and
- Bilge alarms should be provided in each hold fitted with non-weather tight covers.

| | |
|---|---|
| Cargo holds #1 and #5 | 4 supply fans in each cargo hold |
| Cargo holds #3 and #4 | 10 supply fans in each cargo hold |
| Cargo hold #2 | 20 supply fans |

Table 5 - Number of supply fans in cargo holds

1.4.5.2 The location of the supply fans for cargo hold #2 (numbered 05 to 24[106]) are indicated in **figure 24**. The supply fans could be started/ stopped remotely from the Bridge.

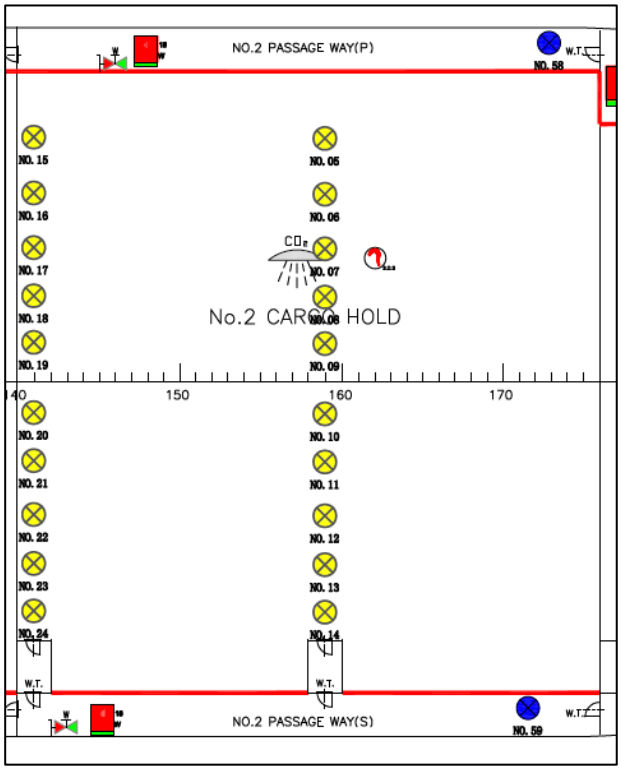



Figure 24 - Total 20 supply fans for cargo hold #2 (coloured yellow and numbered from 05 to 24) - *Source:* LSA Plan provided by the Company

1.4.5.3 Once a supply fan is stopped, a spindle wheel/ key needs to be used to close the flap inside the fan trunking (see **figure 25**). According to the Master, the

[106] Of these 20 fans, no. 07, 08 and 11 were reversible type (supply / exhaust).

supply fans were stopped at about 1215H on 20 May 2021 and flaps inside the trunking were subsequently closed.

Spindle wheel for the supply fan located below the cross deck catwalk


Spindle key for the supply fan located below the cross deck catwalk

Figure 25 - Fan trunking located at the cross deck - *Source:* The Company and XM[107]

1.4.5.4 In addition, all cargo holds had natural ventilation flaps fitted on the sides of the hatch cover panels (as per **table 6** below and **figure 26**) to facilitate air exchange, especially when carrying reefer container.

| | |
|---|---|
| Cargo hold #1 | 12 (6 on each side) |
| Cargo holds #2, #3 and #4 | 36 (18 on each side) in each cargo hold |
| Cargo hold #5 | 18 (9 on each side) |

Table 6 - Number of natural ventilation flaps for the cargo holds

[107] Much of the information obtained was from XM.

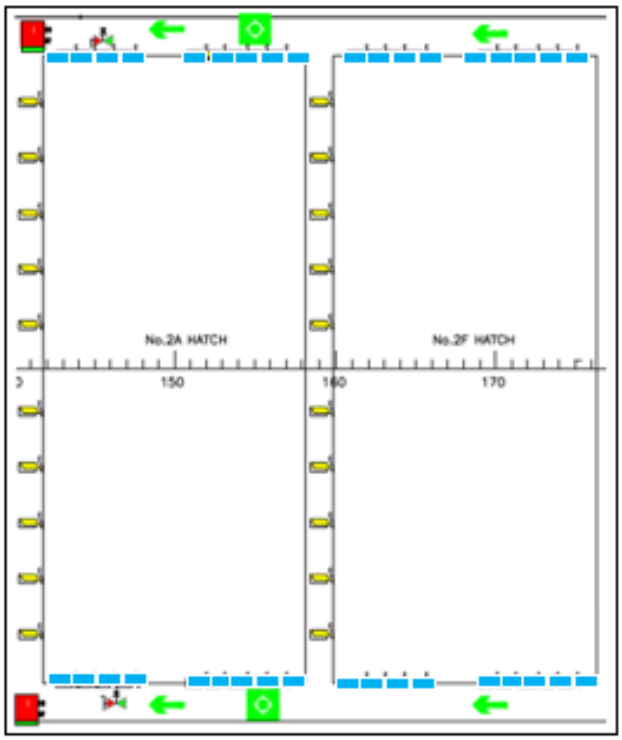



Figure 26 - Ventilation flaps (coloured yellow for mechanical ventilation flaps) and (coloured blue for natural ventilation flaps) for cargo hold #2 - *Source*: LSA plan provided by the Company (*annotation by TSIB*)

1.4.5.5 A total of 96 reefer containers could be carried inside cargo hold #2. These natural ventilation flaps were required to be kept open[108] when carrying reefer containers. At the time of the occurrence, there was no reefer[109] container inside cargo hold #2. Images of the natural ventilation flaps onboard XM are in **figure 27** -:

[108] It was noted that the natural ventilation flaps for cargo hold #2 were in open position.
[109] According to the manifest, there were a total of 34 reefer containers loaded on deck (bays 18, 30 and 38).

| | |
|---|---|
| Port side view of the natural ventilation flaps in closed condition<br><br>(Dashed white circle outline shows the several elevated steps on main deck used to open/ close natural ventilation flaps) |  |
| Starboard side view of the natural vetilation flaps in closed condition |  |

Figure 27 - Port and starboard side view of the natural ventilation flaps as seen from deck level - *Source:* The Company and XM (*annotation by TSIB*)

1.4.6 Simulation of natural ventilation flaps closure onboard XM

1.4.6.1 At the request of the investigation team, a simulation to establish the time taken and the difficulty level for closing the natural ventilation flaps was carried out on XM (see **figures 28 - 30**).

1.4.6.2 The time taken to close one such flap was documented as follows:

- Without wearing a SCBA set i.e. normal work clothes while standing on the elevated step on the main deck – approximately 20-30 sec.

- Wearing a SCBA set and fireman's outfit while standing on the elevated step on the main deck – approximately 50-60 sec.


Figure 28 - Simulation of crew closing the natural ventilation flaps (without container loaded at the bay) - *Source:* The Company

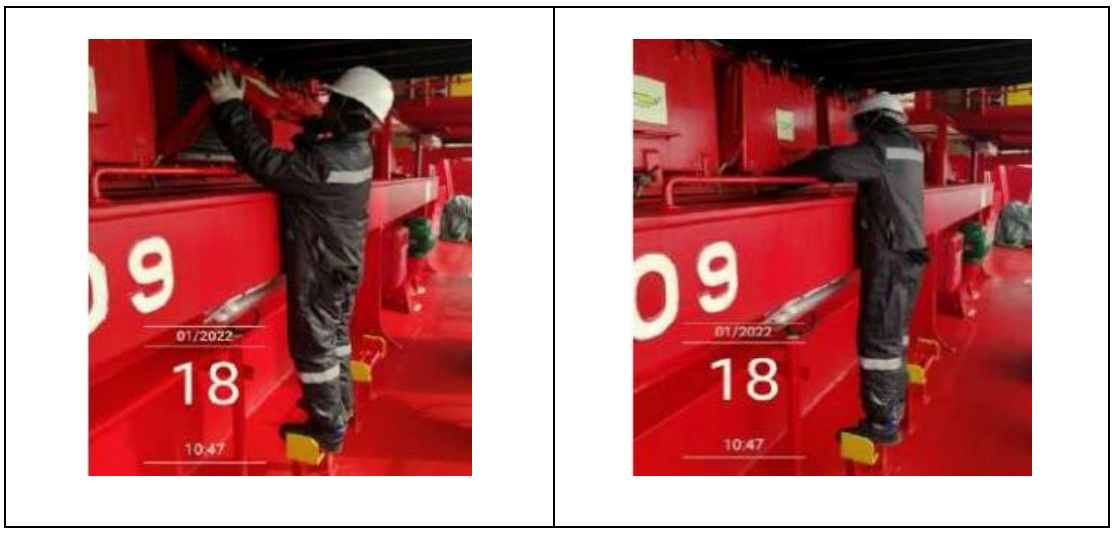



Figure 29 - Simulation of crew closing the natural ventilation flaps (with a container loaded at the bay) - *Source:* The Company


Figure 30 - Simulation of crew closing the natural ventilator flaps while donning the SCBA set and fireman's outfit (without container at the bay) - *Source:* The Company

1.4.6.3 The time taken to close a cluster of five such flaps wearing normal work clothes was about 2.5 minutes and with SCBA set and fireman's outfit was about 5 minutes. The difficulty level according to the crew of XM, on a scale of 1 to 10 (1 being easiest and 10 being most difficult to close a natural ventilation flap), was documented to be a level of 6, due to the vertical lift.

1.5 Smoke detection and firefighting system

1.5.1 According to XP's Fire Control and Safety Plan, there were three control panels for fire detection and alarm system[110] – Bridge, ECR and FCS (at the Upper deck), and two control panels for the sample extraction smoke detection system – Bridge and $CO_2$ Room.

1.5.2 The location of the supply fans for cargo hold #2 (no. 05 to 24) are indicated in **figure 24**. The supply fans could be started/ stopped remotely from the Bridge.

1.5.3 Display of Operation Panel Instruction for sample extraction smoke detection

[110] SOLAS Chapter II-2 (Construction – Fire Protection, Fire Detection and Fire Extinction) Regulation 7 (Detection and alarm).

system as shown in **figure 31**.

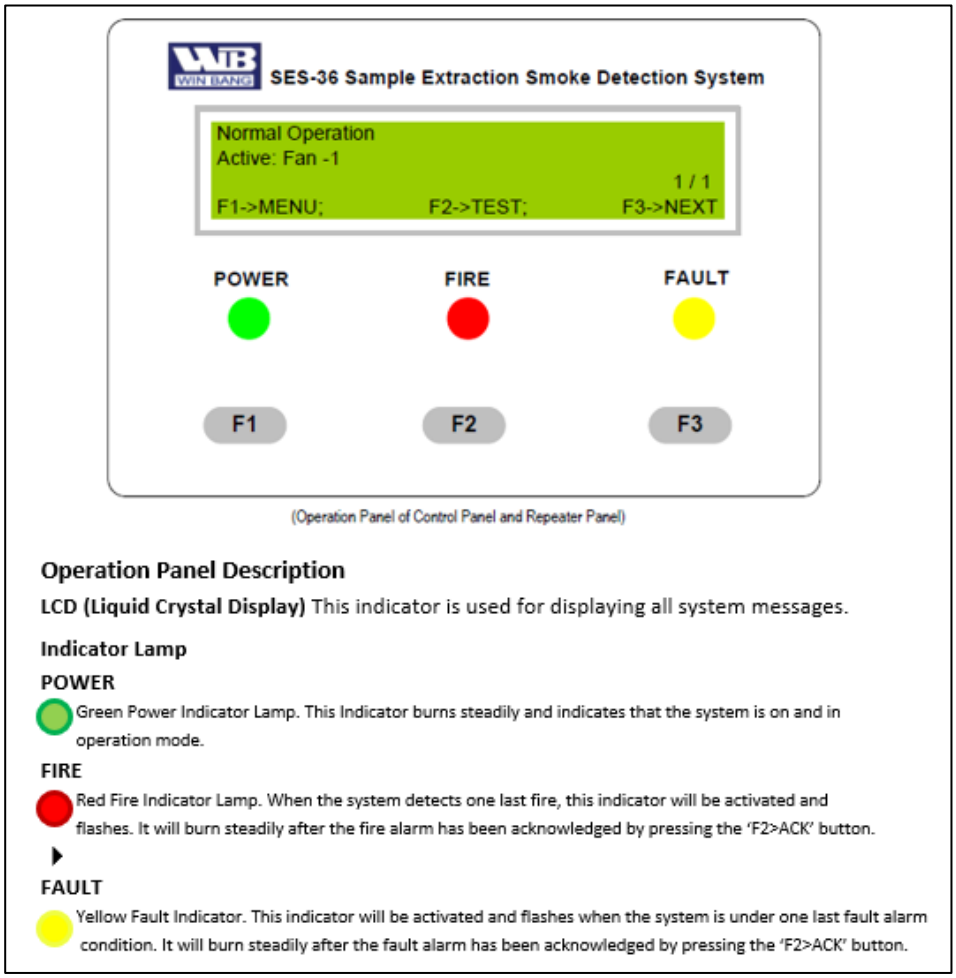



Figure 31 - Instruction panel for the sample extraction smoke detection system - *Source:* The Company

1.5.4 XP was provided with a fixed $CO_2$ fire extinguishing system for the E/R and cargo holds. The $CO_2$ bottles were stored in the $CO_2$ Room, capable of being activated by a control panel located in the $CO_2$ Room and FCS.

1.5.5 The operating instructions for the fixed $CO_2$ fire extinguishing system were inscribed on a metal plate (30cm x 42cm) bonded inside the $CO_2$ Room and FCS as well as on the Bridge. In addition to the operating instructions, the metal plate also contained information on how many bottles of $CO_2$ were to be released into the cargo hold(s) depending on the loading condition (i.e. cargo

volume).

1.5.6 The investigation team noted from these instructions that if cargo hold #2 was 67-100% full (which was the condition during this voyage), 57 bottles were to be released by activating valve no.4. It is further noted that 170 bottles were to be released if the loading condition in cargo hold #2 was zero to 33%, see **Table 7**.

| Loading Condition | Valve No. | Cargo Hold | | | | |
|---|---|---|---|---|---|---|
| | | No.1 | No.2 | No.3 | No.4 | No.5 |
| **0%~33%** | **2** | **89** | **170** | **175** | **171** | **72** |
| **33%~67%** | **3** | **60** | **114** | **117** | **114** | **48** |
| **67%~100%** | **4** | **30** | **57** | **59** | **57** | **24** |

Table 7 - Number of $CO_2$ bottles to be released based on loading condition – *Source:* The Company (*annotations by TSIB*)

1.5.7 The steps to release $CO_2$ into the cargo hold (see **table 8**) are as below:

**IN CASE OF FIRE IN CARGO HOLD**

**Go to release cabinet and supply cabinet located at CO2 room.**

1. **Ensure the key has been taken from the key box.**
2. **Open the supply cabinet door. Open any one pilot cylinder top valve.**
3. **Open related C/H release cabinet door. Alarm Send to AMS.**
4. **Ensure all personnel have been evacuated from the space.**
5. **Stop ventilation fans and close all doors, opening and dampers of related C/H.**
6. **Open the first discharge valve (no.1) for main valve.**
   - **Solenoid valve of related smoke detection piping will be closed automatically (if the solenoid valve can't be closed automatically, please close related emergency ball valve manually).**
7. **Open the second discharge valve (no.2/3/4) according to different cargo loading condition.**
8. **Discharge of the CO2 will begin approximately 30-40 seconds after the second discharge valve have been opened.**

Table 8 - Operating instructions for the release of $CO_2$ into cargo hold - *Source:* The Company (*annotations by TSIB*)

1.5.8 A total of 174 bottles were released into cargo hold #2, of which 170 bottles were by activating valve no.2 (see **figure 32**) and four more bottles (meant for cargo hold #3) were released manually. The investigation team could not establish the rationale for valve no.2 to be activated by XP's crew, instead of valve no.4.

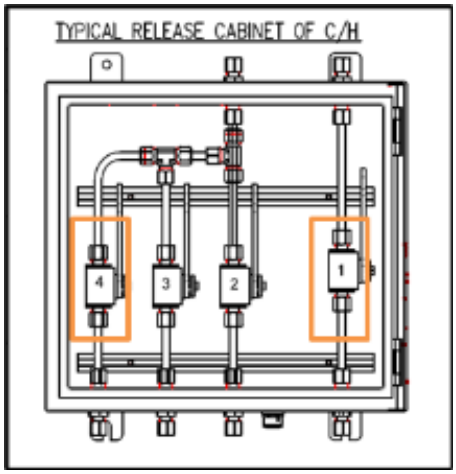



Figure 32 - Discharge valves arrangement for release of $CO_2$ into cargo hold #2 - *Source:* The Company (*annotations by TSIB*)

1.5.9 Portable firefighting extinguishers[111]

1.5.9.1 The investigation team also noted the following from XP's Fire Control and Safety Plan:

- On deck – Two portable DCP extinguishers were located near bay 23, one on the port side and the other on the starboard side. In addition, at the bow, one DCP extinguisher was located inside the BSN Store, and another DCP was located inside the Paint Store.
- Under deck/ passageway – Two portable DCP extinguishers were located aft of cargo hold #4, one on the port side and the other on the

[111] An extinguisher which is designed to be carried and operated by hand, and which in working order has a total weight of not more than 23kg. *Source*: FSS Code.

starboard side passageway. There were also two extinguishers in the ECR – one $CO_2$ and one DCP. The A-2E took the portable $CO_2$ from the ECR.

1.5.10 Personal protection equipment

1.5.10.1 The EmS Guide of Nitric Acid stated the "use of SCBA sets and appropriate chemical protection (e.g., chemical suit) is recommended".

1.5.10.2 When the four shore personnel boarded XP, the SCBA sets were transferred from the port side gangway to cargo hold #2. The investigation team noted during its interaction with some of the crew that the SCBA sets were not used during the boundary cooling and firefighting efforts, because the situation was very chaotic at the time. The OS-2 confirmed that like the SCBA sets, the fireman's outfits were also not used while closing the ventilation flaps.

1.5.10.3 During the firefighting, the Master updated the Company of the developments using the Standard Emergency Report form. Among others, the information updated to the Company included that the SBCA sets were leaking.

1.6 Crew's qualification, experience, and training

1.6.1 At the time of the occurrence, XP had a total of 25 crew including the Master. The crew comprised two from Russia, 14 from China, five from India, and four from the Philippines. Information relating to relevant personnel is in **table 9.**

| **Rank (Nationality)** | **Age** | **Certification Issuing Authority** | **Experience** | | **Sign-on date Country** |
|---|---|---|---|---|---|
| | | | **Year in rank** | **Year with Operator** | |
| Master (Russian) | 50 | COC[112], Master, II/2, Russia | 2.9 | 0.7 | 27 Apr, Singapore |
| CO (Chinese) | 39 | COC, Master, II/2, China | 5 | 0.3 | 10 Feb, Zhoushan, China |
| A-CO (Indian) | 35 | COC, Master, II/2, India | 5 | 1.3 | 15 May, Hazira, India |
| 2O (Chinese) | 27 | COC, Deck Officer, II/1, China | 0.8 | 0.3 | 10 Feb, Zhoushan, China |

[112] Certificate of Competency according to the Standards of Training, Certification and Watchkeeping (STCW).

| | | | | | |
|---|---|---|---|---|---|
| A-2O (Indian) | 33 | COC, Deck Officer, II/1, India | 1.6 | 1.7 | 15 May, Hazira, India |
| 3O (Chinese) | 34 | COC, Deck Officer, II/1, China | 3 | 0.3 | 10 Feb, Zhoushan, China |
| CE (Russian) | 40 | COC, Chief Engineer, III/2, Russia | 5 | 2 | 27 Apr, Singapore |
| 2E (Chinese) | 38 | COC, Second Engineer Officer, III/2, China | 0.8 | 0.3 | 10 Feb, Zhoushan, China |
| A-2E (Indian) | 34 | COC, Second Engineer Officer, III/2, India | 1.8 | 3.8 | 15 May, Hazira, India |
| EO (Chinese) | 47 | COC, Electro-Technical Officer, III/6[113], China | 2 | 0.3 | 10 Feb, Zhoushan, China |
| OS1 (Chinese) | 18 | STCW VI/6 for deck crew, China | 0.25 | 0.25 | 10 Feb, Zhoushan, China |
| OS2 (Chinese) | 31 | STCW VI/6 for deck crew, China | 0.25 | 0.25 | 10 Feb, Zhoushan, China |

Table 9 - Crew matrix of XP

1.6.2 All crew had undergone training for firefighting which included the donning of SCBA set as required by the provisions of STCW Table A-VI/1-2[114] and those possessing a certificate of competency had undergone relevant training under STCW Table A-VI/3[115] and held appropriate certificates.

1.6.3 The rest hour records of the crew could not be obtained as they were lost with the ship. During the interview, there was no mention of fatigue by any of the crew prior to the fire. However, the 3O recalled that after the fire was discovered, many officers and crew were working continuously.

[113] Persons assessed are required to have adequate knowledge of the English language to enable the officer to use engineering publications and to perform the officer's duties. This is to be demonstrated by examination and assessment of evidence obtained from practical instructions by interpreting English language publications relevant to the officer's duties and understanding communications clearly. *Source*: STCW A-III/6.

[114] Specification of minimum standard of competence in fire prevention and firefighting. Table A-VI/1-2 is part of Basic Safety Training for all seafaring personnel.

[115] Specification of minimum standard of competence in advanced firefighting. Table A-VI/3 is for deck and engineering officers qualifying for a Certificate of Competency.

1.6.4 The investigation team gathered that when the general emergency alarm sounded on 20 May 2021 afternoon, the off-signers mustered at the poop deck but were not tasked with any specific duties after the release of $CO_2$ and did not participate in the firefighting response. They were subsequently waiting inside the accommodation until their disembarkation on 23 May 2021.

1.6.5 The Master was conversant with the Company's SMS and attended the pre-joining briefing virtually through Microsoft Teams Meeting on 15 April 2021 prior to joining XP.

1.6.6 English language and proficiency

1.6.6.1 The official language onboard XP was English. Language[116] difficulties were cited by the EO between him and the CE, and the EO mentioned that he was using pictures inside manuals to explain when there were clarifications needed by the CE, instead of verbalising his response.

1.6.6.2 The EO also indicated that because he was not fluent in English, he could not understand what the A-2E said to him while they were at the entrance of $CO_2$ Room. In addition, although the shipboard working language was English, it was a normal practice for the 3O to translate the Master's PA announcements from English to Mandarin for the benefit of the Chinese crew.

1.6.6.3 The investigation team was able to converse with the non-Chinese crew in English. However, conversations with the Chinese crew in English required translation as language barriers were evident. The investigation team further gathered that these language barriers posed a challenge during shipboard operation between the Russian and the Chinese officers, particularly between the Master and the CO, the EO and the CE/ A-2E, as well as among the Filipino[117] and the Chinese deck crew.

1.6.6.4 The Company clarified that there were two sets of crew members onboard and the crew (who were on active duty) at the time of the incident were proficient

[116] Recognising the wide use of the English language for international navigational communications and the need to assist maritime training institutions to meet the objectives of the safe operations of ships and enhanced navigational safety, through *inter alia*, the standardisation of language and terminology used, the IMO adopted IMO Res. A.918(22), referred to as the IMO Standard Marine Communication Phrases (SMCP).
[117] The Filipino ASDs used their personal mobile phone's translation app for communicating with the Chinese crew.

in English. According to the Company, when XP was delivered, after being built in Zhoushan, China, due to Covid-19 travel restrictions at the time, only Chinese crew were able to be employed. Subsequently, relief of Chinese crew was complicated as they were unable to sign-off the ship in certain ports due to border control measures.

1.6.6.5 The investigation team further noted that the SMCP is required for the certification of officers in charge of a navigational watch on ships of 500GT or more. The SMCP builds on a basic knowledge of the English language. It is not intended to provide a comprehensive maritime English syllabus.

1.6.6.6 The investigation team also gathered that although many investigations of marine casualties have identified issues related to the English language, there was a consensus that existing provisions within the STCW and expectations within the ISM Code are sufficient to ensure that crew of a ship are able to converse effectively in the established working language.

1.6.6.7 It is also established that the maritime industry does not have an English proficiency requirement. Many seafarers do not have English as their native language. The investigation team reached out to the International Maritime Lecturers' Association (IMLA) for their views on this matter as discussed during the International Maritime English Conference (IMEC). The investigation team gathered[118] that "assessments by Marlins[119] are offered for the purpose of training.

1.6.6.8 According to the Study, an universal test of Maritime English proficiency, leading to an assessment or possibly even a qualification, would not only level the linguistic field but would also raise the Maritime English bar and, consequently, enhance communication on board and substantially improve safety. The Study, recognising that the inability of a Maritime English test to be passed, could affect the global manning market over a period, further noted that eventually competence would gradually improve with consequent advantages for safety on board.

[118] The feasibility and desirability of setting global standards for Maritime English: a survey-based study (The Study) – Dr Alison Noble, Chair of IMEC

[119] http://www.marlins.co.uk - Marlins is acknowledged by IMO as having aided IMO committees during revision of Model Course 3.17 Maritime English, 2015. *Source*: The Study.

1.7 The Company and its SMS

1.7.1 The Company was issued with an interim Document of Compliance valid from 18 November 2020 to 17 November 2021. Accordingly, XP was issued with an Interim Safety Management certificate on 14 February 2021 and valid until 13 August 2021.

1.7.2 Handling a leaking cargo container

1.7.2.1 The Company's SMS stated that in case of any leakage (cargo), fire or loss of IMDG container, the charterer's DG department is to be contacted, keeping the Company updated, bearing in mind the importance of maintaining personnel safety, ship safety, environment safety and other cargo safety. Additionally, in the event of a leaking IMDG container, the port authority of the port of arrival is to be informed well in advance through the local agent.

1.7.2.2 Within the SMS the Company's IMDG Cargo instructions – Procedure for the carriage of IMDG cargo further stated that to prepare for any kind of accidents, the following must be read and understood –

- Emergency procedure for ships[120] carrying DG cargo;
- Medical First Aid Guide for accidents involving DG cargo; and
- Risks associated with cargo by understanding the labels.

1.7.2.3 Through its interaction with the crew, the investigation team gathered that when the leak was observed on 11 May 2021, and options were being discussed (between Master and the Operator) for container *FSCU7712264* to be offloaded, although the CO instructed all deck crew to stay clear of the leak container, the other deck officers and deck crew were not aware of the contents and nature of the leaking DG cargo.

1.7.3 Muster List[121] and firefighting response

[120] According to the Company, refers to the EmS of the IMDG Code.
[121]SOLAS III/8.2 – Clear Instructions to be followed in the event of an emergency shall be provided for every person onboard. SOLAS III/37.7 – The muster list shall be prepared before the ship proceeds to sea. After the muster list has been prepared, if any change takes places in the crew which necessitates an alteration in the muster list, the master shall either revise the list or prepare a new list.

1.7.3.1 According to the Company's SMS, duties of the crew onboard in the muster list, in the event of a fire, are indicated as Bridge[122] team, Emergency[123] team, Back Up[124] team, Support[125] team and Special Duty team[126].

1.7.3.2 The muster list also stated that "If the fire detection system activates a continuous or intermittent ringing of fire alarm, then it should be accompanied by the general emergency alarm from the Bridge with announcement on PA". On sighting a fire, according to the SMS, the crew should raise the alarm using the nearest manually operated call point[127], shout "Fire, Fire" and alert the duty watchkeeping officer on the Bridge. The duty officer should then sound the general emergency alarm and follow up by an announcement over the PA system on the nature of emergency.

1.7.3.3 As all records were lost with XP, it could not be established whether XP's muster list had specified details for the new crew who joined in Hazira. Likewise, it could not be established whether the roles of off-signers had been identified in a revised muster list for the period they were expected to stay onboard.

1.7.3.4 Through the investigation team's interaction with the crew, it was gathered that the firefighting response and boundary cooling were not as per the prescribed muster list. The A-CO clarified that the situation was rapidly changing, and the available crew had to be deployed to carry out the required tasks (including

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[122] Comprising the Master, 3O and ASD-1.

[123] Led by the CO to fight the deck emergencies. In case of E/R emergency, the Back Up team led by the 2E will take charge, and Emergency team will act as Back Up team. The respective team consists of four crew including either the CO or 2E as the in- charge (I/C).

- The I/C is to report to Bridge all events at the scene of the fire and execute the Master's orders accordingly.
- The BSN is the leader of the fire hose party and reports to the I/C.
- The other two ASDs will bring the fireman's outfit and don them. Additional fire extinguishers will be brought to the fire scene if needed.

[124] Responsible for:

(a) Closing of watertight doors, fire doors, skylights, portholes, and ventilators etc.
(b) Equipping and preparing survival craft.
(c) Bringing contingency/spill equipment to the emergency site.
(d) Bringing spare BA bottles and fire extinguishers as required. Prepare fire hoses, start boundary cooling as instructed.
(e) For all emergencies, they will act as back up for response measures and provide support to the Emergency team.

[125] Led by the 2O. Primarily responsible for first aid, and then assist the Back Up team as required.

[126] Led by the CE, On-scene Coordinator and supported by the EO with duties includes, checking the emergency lighting and emergency generators.

[127] 51 units fitted onboard the ship.

closure of ventilation flaps). The A-CO further added that he did not know the deck crew well as he just signed-on five days ago. The A-CO confirmed that the off-signing crew's assistance was not sought actively by him during the entire emergency. Reasons for this could not be explained by the A-CO.

1.7.3.5 The Company's SMS stated that the CE was designated to release the $CO_2$. The decision to use the $CO_2$ system was by the Master, acting on advice from the other two senior officers, i.e. the CE and the A-CO.

1.7.4 Emergency drills

1.7.4.1 According to SOLAS III/19/3.2[128] fire drills are to be held monthly to cover various scenarios onboard. The Company's SMS had a drill schedule which served as a guide to their fleet of ships. According to the crew, the last fire[129] drill held onboard was on 16 May 2021 after XP departed Hazira, and the scenario was fire in the galley. During this drill the fireman's outfit and SCBA sets were reportedly used to satisfaction. The crew added, since the ship was delivered in February 2021, there was no fire drill scenario involving cargo hold fire.

1.7.4.2 The investigation team sought from the Company whether any of the crew of XP had participated in a fire drill involving a cargo hold fire. The Company confirmed that the A-CO[130] and the A-2E[131] had, within a year, participated in such drill during their tenure on previously assigned ships.

1.7.4.3 The investigation team gathered that there were no specific procedures in the SMS to ensure its officers were familiar with the $CO_2$ system prior to handing-over/taking-over duties when there is a crew-change. The Company clarified that shipboard training for $CO_2$ system was done two-monthly in accordance with its SMS. This training onboard XP was due but had not been carried out.

[128] Every crew member shall participate in at least one abandon ship drill and one fire drill every month. The drills shall take place within 24H of the ship leaving a port if more than 25% of the crew have not participated in abandon ship and fire drill onboard that particular ship in the previous month.
[129] Per duties in the muster list in the event of fire, the ASD-1 was the helmsman on the Bridge (Command team), the ASD-2 was in the Support team together with one OS and was tasked to rig fire hose(s) for boundary cooling, and the ASD-3 was in the Emergency team (firefighting).
[130] The A-CO last participated in the fire drill when serving onboard X-Press Lhotse.
[131] The A-2E last participated in the fire drill when serving onboard X-Press Yamuna.

1.7.5 Additional information from the Company

1.7.5.1 The Company confirmed that the ERT was on standby ashore since 20 May 2021 ready to provide guidance to the Master when needed. The Company informed the investigation team that they notified ABS' SERS on 21 May 2021 over the phone, which was acknowledged by ABS' SERS and thereafter was also on standby to assist as and when required.

1.7.5.2 On being asked whether the ERT was aware that the Master released 174 bottles of $CO_2$ into cargo hold #2 instead of the appropriate quantity for the volume of cargo loaded, the Company responded that the ERT became aware of the quantity used after the release.

1.7.5.3 The Company confirmed that they did not have a DG desk[132], as booking of cargo were all undertaken by the Operator. Operational concerns pertaining to carriage of DG cargo would be routed back to the Operator for their action.

1.7.5.4 On being asked whether flooding of the leaking container *FSCU7712264* was considered, taking the EmS Guide requirements for Nitric Acid into account, the Company was of the view that the quantity of accumulated DG inside the container, due to the leak was unknown. Considering that structural integrity of the container could be compromised, flooding of the leaking container was under constant evaluation, but was not initiated.

1.7.5.5 The Company's SMS section on Master's Authority stated that – The Master is empowered in all situations with overriding authority and responsibility to act decisively and according to his best judgement. The Master may request assistance from an appropriate person in the Company at any time to fulfil these responsibilities. The Company further iterated that they took actions to assist the Master in the situation.

[132] Typically, a department in most container shipping companies which accepts DG bookings with access to stowage planning software which validates stowage requirements per IMDG requirements and the Company's internal DG restriction list.

## 1.8 Procedures – Operator and Shipper

### 1.8.1 Operator's procedures

1.8.1.1 The Operator provides transportation services as an independent container feeder carrier, operating close to 100 ships. They do not own or lease any containers.

1.8.1.2 Any ship operated by the Operator is under the care of one of the Line Manager(s)[133] within the respective hub[134] and a ship planner (located centrally or within the hub). At the time of the occurrence, as per normal practice, booking of DG for carriage was done by stowage planners[135] at the DG desk of the Operator.

1.8.1.3 The Line Manager oversees the commercial operations of the ship and liaises with Shipper and agents. In the correspondence between XP's Master and the Operator, the Line Managers were in constant communication with the Shipper, agents, and terminal operators for handling the leaking container.

1.8.1.4 The Operator's procedure for master[136], relating to DG was – "Should hazardous cargo containers suffer damage or leakage during the time onboard, please immediately notify your Line Manager and ship planner, giving full details of containers and cargoes in order that necessary arrangements can be made at the next port."

1.8.1.5 The booking process (see **figure 33**) for accepting a DG container at the time of the occurrence required the Shipper to complete the DG approval form. Thereafter, the booking is approved (with associated terms and conditions) and sent to the Line Manager for subsequent relay to the Shipper.

[133] Refers to person in-charge of the ship's service trade.
[134] Refers to regional offices e.g., East Asia, South Asia, West Asia etc.
[135] A dedicated role for ensuring proper stowage, who attended IMO IMDG training as required by the IMDG Code 1.3.1 'Training of shore-side personnel'.
[136] The Master has the right to reject any container at the time of loading or at any time the DG commodity becomes dangerous, inflammable, radio-active or damaging, at any place unload, destroy, or render harmless without compensation.

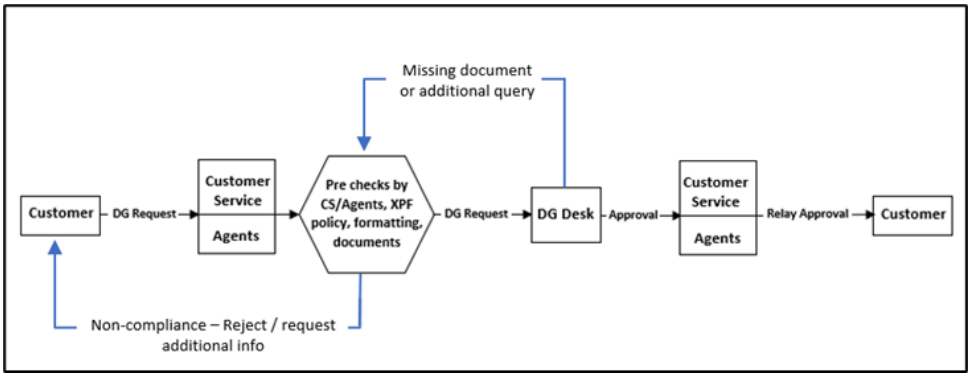


Figure 33 - Extract of DG booking approval process at the time of occurrence - *Source*: The Operator

1.8.1.6 The Operator further added, all DG acceptance is based on Shipper's declaration. All DG containers and commodities within must be stowed, secured, packed, labelled, and stated in the manifest as per current requirements of the IMDG code and its Special Provisions, including any additional requirements of the port of call/ discharge and the requirements of their relevant authorities. The Shipper must ensure that the container – used for stuffing the DG commodity – is in good condition, cargo-worthy and free from any damage.

1.8.2 Shipper's procedures

1.8.2.1 When an Exporter[137] desires to ship any hazardous cargo, the Exporter will provide information about the shipment using a DG approval form, through the Shipper, which is then forwarded to the Operator.

1.8.2.2 Any shortcomings identified by the Operator in the information provided would be brought to the attention of the Exporter for rectification prior to approving the booking. The investigation team noted that the Operator's DG desk approved two containers on 26 April 2021 for loading onboard XM.

1.8.2.3 The Shipper informed the investigation team that they were not aware container *FSCU7712264* had a placard with a subsidiary risk of DG Class 5.1, as this was under the purview of the Exporter.

[137] Exporter is a person or company or entity that is authorised by Customs and Government authorities to export cargoes to various countries and responsible for filling the export declaration with the custom authorities.

1.8.2.4 The investigation team further gathered that on 24 April 2021, two containers [FSCU7712264 (container at position 110582) and GESU2837027] with cargo content of NITRIC ACID were booked by the same Shipper.

1.8.2.5 The Shipper further clarified that the shipment was received from an overseas Exporter through a Freight Forwarder. When asked about documentation pertaining to the declaration of DG, the Shipper clarified that the stacking, packing and preparation of transport documents was done by the Exporter.

1.8.2.6 These documents were forwarded by the Shipper to the Operator. The booking was then accepted based on the Operator's established criteria and approved by the Operator's DG desk. For containers FSCU7712264 and GESU2837027, the approval was based on the information documented in the MDGF and received by the Shipper to be loaded originally onboard XM.

1.8.2.7 The two containers arrived at the Port of Jebel Ali on 3 May 2021 and were stowed at a terminal berth awaiting the arrival of XM. As there was a container rollover on XM, container FSCU7712264 with newly filled MDGF was then loaded onboard XP when the ship called the Port of Jebel Ali on 11 May 2021.

1.9 Cargo onboard XP

1.9.1 The investigation team reviewed the stowage of containers onboard XP from departing the Port of Jebel Ali to departing the Port of Hazira and noted that a total of 362 containers were loaded in bays 09 to 15, of which, 50 were DG containers.

1.9.2 A total of 146 containers were loaded on deck from bays 09 to 15, of which 11 were carrying DG cargo. 216 containers were loaded below deck in cargo hold #2, of which 39 were carrying DG cargo. See **figures 34 and 35** showing the stowage plan of the DG and non-DG cargo on deck and below deck at bays 09 (10) 11.

1.9.3 **Figures 34** and **35** show containers stowed in bays 09 (10) 11, colour coded for the port of discharge, with reference to the eastbound port rotation of Colombo, Port Klang[138], Singapore and Tanjung Pelepas. The DG containers

[138] At bays 09 (10) 11 there were no containers planned for discharge in Port Klang, Malaysia.

were indicated with its conventional labelling of IMDG class while the non-DG containers were indicated to be general cargo as per the cargo list.

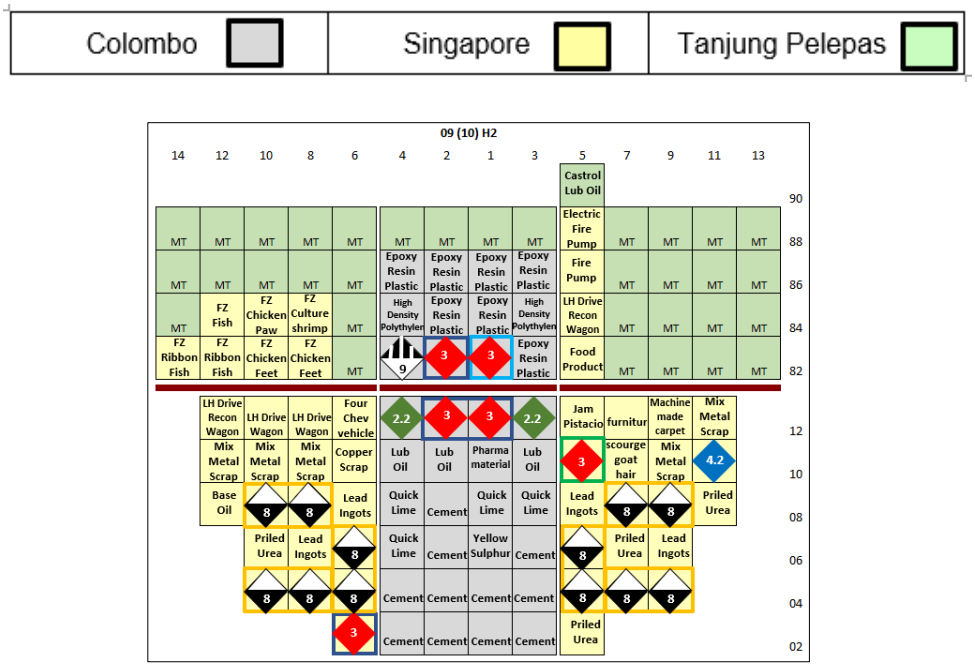


Figure 34 - Showing bays 09 (10) stowage seen from aft (looking forward)

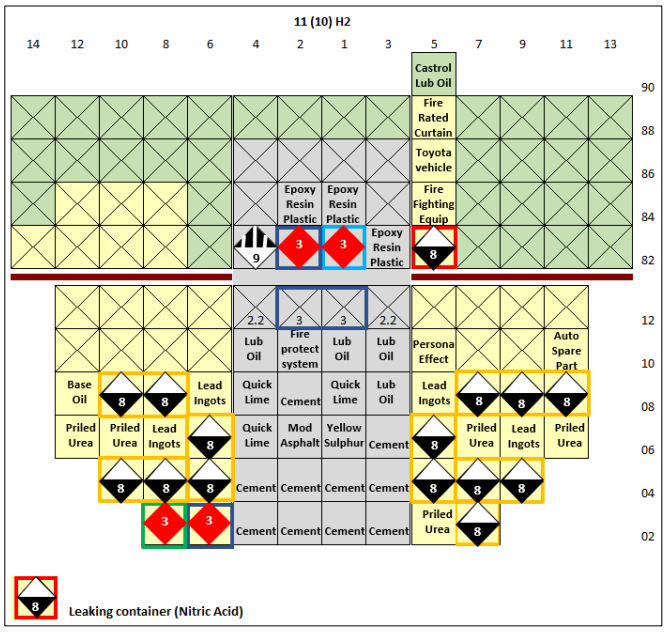

Figure 35 - Showing bay 11 (10) stowage and depicting leaking container *FSCU7712264* with red outline

1.9.4 Container *FSCU7712264*

1.9.4.1 Container *FSCU7712264* was of ISO[139] standard type 2210[140] – 20 feet in length, 8.6 feet in height – general purpose container with ventilation (see **figure 36**). Containers are typically made of Corten Steel which is a copper chromium alloy steel with high concentration of iron and copper.


Figure 36 - (Left) side and (Right) front of container *FSCU7712264* - *Source*: The Company

1.9.4.2 Container *FSCU7712264* was declared using the MDGF (DG approval form in **table 10**) to be carrying an IMDG Class 8 cargo shipped with a Proper Shipping Name (PSN) – NITRIC ACID, under UN number 2031 and originally planned for discharge in Port Klang, Malaysia.

[139] ISO 6346 is an international standard covering the coding, identification and marking of intermodal (shipping) containers. The standard establishes a visual identification system for every container that includes a unique serial number, the owner, a country code, a size, type and equipment category as well as any operational marks.
[140] Type 2210 per the 1984 ISO 6346 Code has been revised to 22G1 in the 1995 Code – passive vents at upper part of cargo space. ISO 6346:1995 (from ISO) *Freight containers – Coding, identification and marking.*

| DG APPROVAL FORM | |
|---|---|
| **MUST NECESSARY DETAILS REQUIRE BY LINE** | **RECEIVED FROM SHIPPER** |
| VSL NAME AND VOY NO. | X-PRESS MEKONG V 21016E |
| NO/ SIZE/ TYPE OF CONATAINER | 2 x 20' |
| PORT OF LOADING | JEA |
| PORT OF DISCHARGE | MYPKG |
| DESTINATION | |
| NUMBER AND TYPE OF OUTER PACKING | 18 IBC |
| NUMBER AND TYPE OF INNER PACKING | NA |
| IS OUTER PACKING U.N TEST MARKED | |
| UN NUMBER | 2031 |
| PROPER SHIPPING NAME | NITRIC ACID |
| CLASS | 8 |
| PACKING GROUP | II |
| GROSS/ NET WEIGHT | 26500 KGS / 25000 KGS |
| FLASHPOINT | NA |
| ANY SUBSIDIARY RISK LABEL | |
| EMS AND MFAG NUMBER | |
| MARINE POLLUTANT | No |
| SOLID OR LIQUID | Liquid |
| EMERGENCY CONTACT | |

Table 10 – MDGF - *Source:* The Operator

1.9.5 Cargo of Nitric Acid and its properties

1.9.5.1 As per UN 2031, NITRIC ACID can be shipped under different concentrations. The PSN is that portion of the entry in the IMDG Code, that most accurately describes the goods in the DG List, which is shown in the upper-case characters. Portions of an entry appearing in lower case need not be considered as part of the PSN but may be used[141]. (See **table 11**).

| | | |
|---|---|---|
| NITRIC ACID other than red fuming, with more than 70% Nitric Acid | NITRIC ACID other than red fuming, with at least 65% but with not more than 70% Nitric Acid | NITRIC ACID other than red fuming, with less than 65% Nitric Acid |

Table 11 - Concentration of Nitric Acid

[141] Part 3.1.2.1 of the DG List of the IMDG Code.

1.9.5.2 The actual cargo contained within container *FSCU7712264* was NITRIC ACID *other than red fuming with at least 65% but with not more than 70% Nitric Acid*, (highlighted yellow in **table 11**) with a subsidiary risk of Class 5.1, as obtained by the investigation team from the MSDS provided by the Operator.

1.9.5.3 Although MSDS is not a mandatory document for the booking of cargo, the investigation team noted that the MSDS provided by the Shipper to the Operator and the Company (a generic document and not for this shipment) stated that the concentration of Nitric Acid was 65 – 70% (see **figure 37**) below.

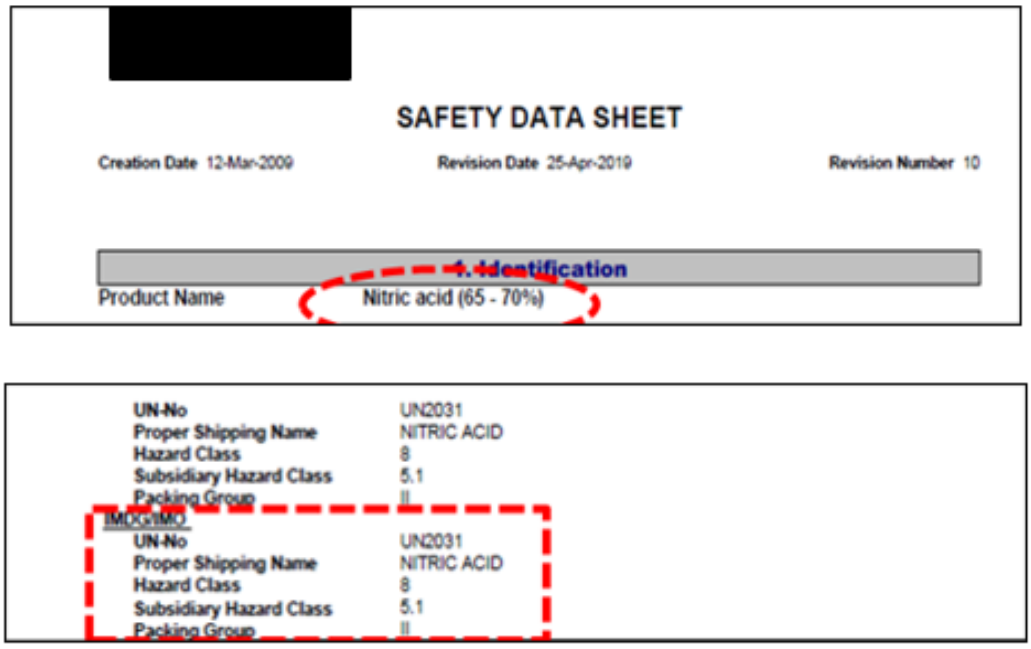


Figure 37 - MSDS provided by the Shipper – *Source:* The Company (*annotation by TSIB*)

1.9.5.4 Relevant sections of the generic MSDS are indicated in **table 12** below –

| | |
|---|---|
| **Appearance** | Clear colourless, light yellow |
| **Odour** | Strong acid |
| **Incompatible materials** | Combustible material, Strong bases, Reducing agents, Metals, Powdered metals, Organic materials, Aldehydes, Alcohols, Cyanides, Ammonia, Strong reducing agents |
| **Fire** | In case of fire: Use $CO_2$, DCP, or foam for extinction |
| **Spills** | Absorb spillage to prevent material damage |

| | |
|---|---|
| **Methods for containment and clean up** | Soak up with inert absorbent material. Keep in suitable, closed containers for disposal. Sweep up and shovel into suitable containers for disposal. Wear SCBA sets and protective suit. |
| **Hazardous combustion and decomposition products** | Nitrogen oxides (NOx), thermal decomposition can lead to release of irritating gases and vapours |
| **Specific hazards arising from Nitric Acid** | Thermal decomposition can lead to release of irritating gases and vapours. The product causes burn of eyes, skin and mucous membranes. Oxidizer: Contact with combustible/organic material may cause fire. May ignite combustibles (wood paper, oil, clothing, etc.). |
| **Protective equipment and precautions for firefighters** | As in any fire, wear SCBA sets and full protective gear. Thermal decomposition can lead to release of irritating gases and vapours. |
| **Personal precautions** | Evacuate personnel to safe areas. Keep people away from and upwind of spill/leak. Ensure adequate ventilation. Use PPE. |

Table 12

1.9.5.5 The investigation team further reviewed some literature[142] which indicates that orange fumes are characteristics of Nitric Acid. While by itself is non-combustible, Nitric Acid is highly corrosive and will react with metal/ wood material (inside the container) in an exothermic (heat generated) manner and start decomposing generating toxic and corrosive fumes.

1.9.5.6 Nitric Acid in contact with metals will also produce hydrogen (flammable) gas. The large quantities exposed within the container can result in further corrosion through the original leakage point. The possibility of Nitric Acid readily reacting with metals, corroding, and seeping under the hatch cover exists. Metals will react with Nitric Acid to form oxides of Nitrogen. Orange/ reddish brown fumes are evidence of oxides of Nitrogen. It was also noted[143] that to avoid a violent reaction, material (Nitric Acid) should be added to water, but water should not be added to the material.

1.9.5.7 Rubber in contact with Nitric Acid can degrade rapidly. According to the Rubber

[142] *Source*: Port Chemist from the Regulator (of the Port of Singapore).
[143] Safety Data sheet by Chemwatch 31-5207 Version 2.1 – Nitric Acid 70%.

Chemical Resistance chart[144], Nitric Acid (red fuming and of concentrations between 50-100%) is not compatible with EPDM and Nitrile rubber, both of which are typical compounds used in the manufacturer of container door seals.

1.9.5.8 Nitric Acid's reaction[145] with rubber chunks derived from vulcanised tyres –

- Results in oxidation, nitration and degradation of rubber which occurs in an exothermic process; and
- May result in fire depending on the type of rubber.

1.9.5.9 The investigation team also gathered that in a lab experiment[146], a few millilitres of Nitric Acid poured over rubber nitrile glove causes smoke to be emitted within 10 seconds and for the glove to catch fire within 20 seconds.

1.9.5.10 Further literature[147] indicates that mixtures of Methanol with more than 5% Nitric Acid are subject to violent decomposition, if heated. Although solutions of Methanol and Nitric Acid are more stable than mixtures of higher alcohols and Nitric Acid, mixtures of 33% Nitric Acid in Methanol have been known to decompose suddenly and violently. On pouring Nitric Acid into Methanol has resulted in brown fumes.

1.9.5.11 Ethanol's (a key component in perfumery products) reaction with Nitric Acid gives off nitrates and water. Once the ratio of Nitric Acid to alcohol rises above 9%, dangerous, violent, and toxic gas forming reactions may occur, as noted in a laboratory incident[148].

1.9.5.12 The investigation team further gathered[149] that when Caustic Soda reacts with Nitric Acid, Sodium Nitrate and water are produced which are exothermic. Sodium Nitrate is an oxidiser, can be a fire risk near organic materials, ignites

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[144] https://mykin.com – Rubber Chemical Resistance Compatibility. *Source*: Health Sciences Authority (HSA) Singapore.
[145] https://www.researchgate.net/publication/289655361 - Interaction of Nitric Acid with rubber chunks derived from waste tyres. *Source*: HSA Singapore.
[146] https://www.youtube.com/watch?v=t2xuszdLRko. *Source*: HSA Singapore.
[147] Laboratory Safety in Metallography, Metallography and Microstructures, Vol 9, ASM Handbook, ASM International, 2004, p. 1081–1090. *Source*: HSA Singapore
[148] University of Waterloo – Explosion from inappropriate disposal of mixture of Nitric Acid and Ethanol, 2016. *Source*: HSA Singapore.
[149] Larranaga, M. D.; Lewis, Sr. R. J.; Lewis, R. A. Hawley's Condensed Chemical Dictionary, Sixteenth edition; Wiley: New Jersey, 2016; pp 1247. *Source*: HSA Singapore.

on friction and explodes when shocked or heated to 537°C.

1.9.5.13 In establishing the reaction of Nitric Acid with sawdust[150] it was noted that formation of nitrocellulose is possible due to nitration. It was also established that to soak and contain minor leaks of Nitric Acid, sand, earth or inert material is more suitable.

1.9.6 Nitric Acid – Packaging

1.9.6.1 According to the IMDG Code, packing of Nitric Acid in IBCs is authorised using the following materials:

- Metal – Steel, aluminium, other than steel or aluminium;
- Rigid plastics – fitted with structural equipment designed to withstand the whole load when IBCs are stacked, freestanding; and
- Composite with plastics inner receptacle – rigid plastic inner receptacle

1.9.6.2 According to the IMDG Code, for UN 2031 with more than 55% Nitric Acid, the permitted use of rigid plastics IBCs and of composite IBCs with a rigid plastic inner receptacle shall be no more than two years from their date of manufacture (B15).

1.9.7 DG documentation

1.9.7.1 According to the IMDG Code 5.4.1[151], each ship carrying DG is required to have a manifest or stowage plan setting out the location of the DG containers.

1.9.7.2 The investigation team noted that the EmS in the manifest provided by the Shipper of container *FSCU7712264* (Nitric Acid) was F-A | S-B[152], see **table 13.**

[150] Cellulose constituents - Trends in Analytical Chemistry, Vol. 30, No. 11, 2011. *Source*: HSA Singapore.
[151] DG transport information. The DG transport document (DG list or manifest) shall contain, the UN number preceded by the letters “UN”, proper shipping name, the primary hazard class, the subsidiary hazard class and the packing group.
[152] FIRE SCHEDULE Alfa | SPILLAGE SCHEDULE Bravo.

| Position | Serial Number | POL | POD | Type | Weight | IMDG-Class | UNNo | EmS | EmS |
|---|---|---|---|---|---|---|---|---|---|
| 110582 | FSCU7712264 | AEJEA | MYPKG | 2210 | 28.7 | 8 | 2031 | F-A | S-B |

| Sl. No | Container No | SEAL NO | ISO TYPE | LINE | Shipper | Consginee | No of PCS | Gr. WT | POL | FPOD | Description (Same as in the B/L) | IMCO Class | UN No |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | FSCU7712264 | 8197 | 2210 | XX | XX | XX | 18 IBC | 28700 | AEJEA | IDJKT | Nitric Acid HS Code: 28080010 | 8 | 2031 |

Table 13 - Manifest from the Shipper - *Source*: The Company

1.9.7.3 According to the IMDG Code, a spillage schedule of S-B is applicable for 'NITRIC ACID, other than red fuming, with less than 65% Nitric Acid'.

1.9.7.4 The investigation team also noted that the email from the agent to Hazira terminal operator indicated that the cargo onboard was 'NITRIC ACID other than red fuming, with more than 70% Nitric Acid'. The EmS mentioned in this email was also S-B (see **table 14**).

| | DG leakage FSCU 7712264 | | | | | | |
|---|---|---|---|---|---|---|---|
| SN | Position | Serial Number | POL | POD | Type | Weight | IMDG-Class |
| 1 | 110582 | FSCU7712264 | AEJEA | MYPKG | 2210 | 28.7 | 8 |

| | | | | | |
|---|---|---|---|---|---|
| UNNo | EmS | EmS | Proper Shipping Name | | |
| 2031 | F-A | S-B | NITRIC ACID | other than red fuming | with more than 70% nitric acid |

Table 14 - Description provided by the agents in India to Hazira terminal operator - *Source*: The Company

1.9.7.5 The investigation team further gathered that the Operator's software for DG manifest captured details of the cargo as 'NITRIC ACID other than red fuming, with more than 70% Nitric Acid'.

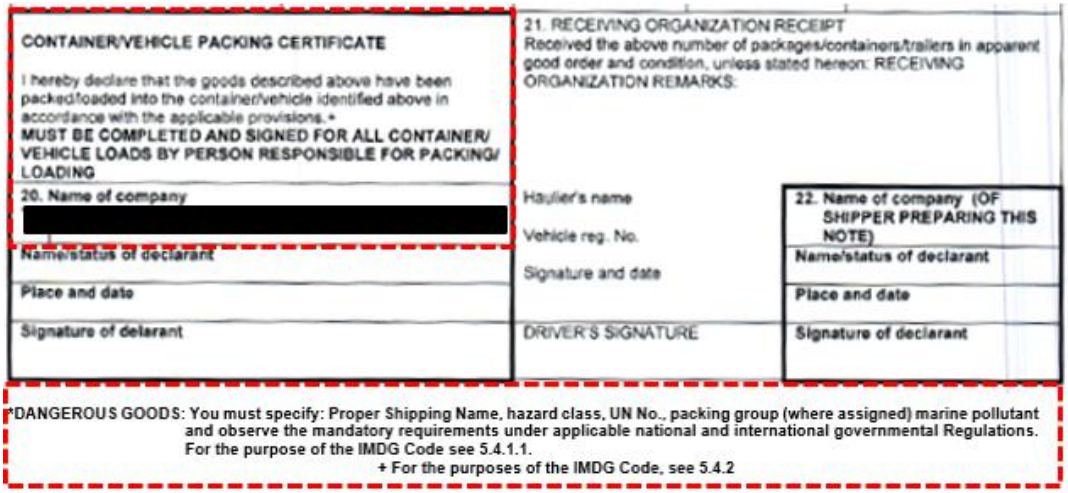
1.9.7.6 The IMDG Code 5.4.5 prescribes[153] a non-mandatory format of the MDGF which is typically adapted across the industry, albeit the layout and contents which may be different.

1.9.7.7 The IMDG Code 5.4.2 requires that when DG are packed or loaded into any container or vehicle, those responsible for packing the container or vehicle shall provide a "container/ vehicle packing certificate" specifying the identification number and that the operation have been carried out in accordance with certain conditions, which include the following:

- the container/ vehicle was clean, dry and apparently fit to receive the goods;
- all packages have been externally inspected for damage and only sound packages have been loaded; and
- the container/ vehicle and packages have been properly marked, labelled and placard, as appropriate.

1.9.7.8 A review of the MDGF (see **table 15**) indicated that the Shipper had declared that the DG cargo described within were packed and loaded in accordance with applicable regulations of the IMDG Code. This declaration, according to the Shipper, was done in good faith based on the Exporter's declaration to the Shipper.

[153] SOLAS, chapter VII, regulation 4: Documents
(a) Transport information relating to the carriage of dangerous goods in packaged form and the container/vehicle packing certificate shall be in accordance with the relevant provisions of the IMDG Code and shall be made available to the person or organization designated by the port State authority.
(b) Each ship carrying dangerous goods in packaged form shall have a special list, manifest or stowage plan setting forth, in accordance with the relevant provisions of the IMDG Code, the dangerous goods onboard and the location thereof. A copy of one of these documents shall be made available before departure to the person or organization designated by the port State authority.



CONTAINER/VEHICLE PACKING CERTIFICATE

I hereby declare that the goods described above have been packed/loaded into the container/vehicle identified above in accordance with the applicable provisions.+
MUST BE COMPLETED AND SIGNED FOR ALL CONTAINER/ VEHICLE LOADS BY PERSON RESPONSIBLE FOR PACKING/ LOADING

20. Name of company

Name/status of declarant

Place and date

Signature of delarant

21. RECEIVING ORGANIZATION RECEIPT
Received the above number of packages/containers/trailers in apparent good order and condition, unless stated hereon: RECEIVING ORGANIZATION REMARKS:

Haulier's name

Vehicle reg. No.

Signature and date

DRIVER'S SIGNATURE

22. Name of company (OF SHIPPER PREPARING THIS NOTE)

Name/status of declarant

Place and date

Signature of declarant

*DANGEROUS GOODS: You must specify: Proper Shipping Name, hazard class, UN No., packing group (where assigned) marine pollutant and observe the mandatory requirements under applicable national and international governmental Regulations. For the purpose of the IMDG Code see 5.4.1.1.
+ For the purposes of the IMDG Code, see 5.4.2

Table 15 – MDGF - *Source:* The Company

1.9.7.9 As noted in **table 11**, Nitric Acid can be shipped in three concentration grades. The MDGF of container *FSCU7712264* contained an incomplete PSN (with concentration) and did not indicate the packing group.

1.9.7.10 Appropriate information for use in an emergency[154] i.e., 24 hours emergency telephone number is to be readily available in accordance with the IMDG Code 5.4.3.2. The information shall be available away from packages containing the DG and immediately accessible in the event of an incident.

1.9.7.11 The investigation team noted that an emergency response number was available in the MSDS and in the Operator's DG approval form. The investigation team could not establish whether the emergency response number was used by XP's crew to seek advice on handling the Nitric Acid when it leaked from container *FSCU7712264*.

1.9.8 Requirements from EmS Guide – Spillage

1.9.8.1 According to the IMDG Code, the EmS spillage schedule of S-Q is applicable for Nitric Acid of concentration between 65 – 70% (which was the concentration of Nitric Acid of container *FSCU7712264* and for Nitric Acid of concentration

[154] Appropriate entries in the DG list / DG manifest / DG declaration / MSDS / EmS Guide / MFAG.

more than 70%. Relevant comparison of both schedules is in **table 16** below.

| | | S – B | S – Q |
|---|---|---|---|
| | | Corrosive Substance (Class 8) | Oxidising Substances (Class 5.1) |
| General Comments | | Wear suitable protective clothing and self-contained breathing apparatus. Avoid contact, even when wearing protective clothing. Keep clear of effluent. Keep clear of evolving vapours. Even short-time inhalation of small quantities of vapour can cause breathing difficulties. Use of water on the substance may cause a violent reaction and produce toxic vapours. Substance may damage ship's construction materials. Contaminated clothing should be washed off with water and then removed. | Wear suitable protective clothing and self-contained breathing apparatus. Avoid all sources of ignition (e.g., naked lights, unprotected light bulbs, electric hand tools, friction). Wear non-sparking footwear. May ignite combustible material (e.g., wood, paper, clothing). Stop leak if practicable. |
| Spillage on deck | Packages (small spillages) | Wash overboard with copious quantities of water. Do not direct water jet straight onto the spillage. Keep clear of effluent. Clean the area thoroughly. | Wash overboard with copious quantities of water. Keep clear of effluent. |
| Spillage under deck | Packages (small spillages) | Provide adequate ventilation. Do not enter space without self-contained breathing apparatus. Check atmosphere before entering (toxicity and explosive hazard). If atmosphere cannot be checked, do not enter. Let vapour evaporate. Keep clear.<br><br>Liquids: Provide good ventilation of the space. Wash down to the bottom of the hold. Use copious quantities of water. Pump overboard.<br><br>Solid: Collect spillage. Dispose overboard. Wash residues down to the bottom of the hold. Use copious quantities of water. Pump overboard. | Do not enter space without self-contained breathing apparatus.<br><br>If dry: contain and collect spillage if practicable. Dispose overboard.<br><br>If wet: use inert absorbent material. Do not use combustible material.<br><br>If liquid was down to the bottom of the hold using copious quantities of water.<br><br>Pump overboard.<br><br>Dispose overboard. |

Table 16 - Requirements from EmS Guide – Spillage

1.9.9 Requirements from EmS Guide – Fire

1.9.9.1 The EmS Fire schedule for Nitric Acid of any concentration and Caustic Soda is F-A according to the IMDG Code, and F-E for Methanol. See **table 17** below.

| | | F – A | F – E |
|---|---|---|---|
| | | Nitric Acid and Caustic Soda | Methanol |
| General Comments | | In a fire, exposed cargoes may explode, or their containment may rupture. Fight fire from a protected position from as far away as possible. | Cargoes in tanks exposed to heat may explode suddenly in or after a fire situation by a Boiling Liquid-Expanding Vapour Explosion (BLEVE). Keep tanks cool with copious quantities of water.<br>Fight fire from a protected position from as far away as possible. Stop leakage or close open valve if practicable. Flames may be invisible. |
| Cargo on fire on deck | Packages | Create water spray from as many hoses as possible. | Create water spray from as many hoses as possible. |
| Cargo on fire under deck | | Stop ventilation and close hatches.<br>Use cargo space fixed fire-extinguishing system. If this is not available, create water spray using copious quantities of water. | Stop ventilation and close hatches.<br>Use cargo space fixed fire-extinguishing system. If this is not available, create water spray using copious quantities of water. |

Table 17 - Comparison of EmS

1.9.10 Relevant DG and non-DG cargo in the vicinity of container *FSCU7712264*

1.9.10.1 The DG cargo onboard XP in the vicinity of container *FSCU7712264* (see **Appendix 3**) were as follows: –

- Methanol - Class 3 with a subsidiary risk 6.1 (about 158 metric tonnes)
- Vinyl Acetate, Stabilised – Class 3 (about 46 metric tonnes)
- Assorted Perfumes – Class 3 (about 17 metric tonnes)
- Sodium Hydroxide (named 'Caustic Soda' in the manifest about 637 metric tonnes) – Class 8

1.9.10.2 Methanol (see **Appendix 2a**) is a combustible material with a flashpoint of 12°C. In the event of fire, suitable extinguishing agents include $CO_2$, DCP or foam. Methanol vapours may form explosive mixtures with air thereby causing a risk of ignition/ explosion when heated. Exposure to excess heat, flames or sparks should be avoided. This cargo, stowed and segregated as per the IMDG Code, could be carried on deck or below deck. (See **figures 34 and 35** – outlined with darker blue square).

1.9.10.3 Vinyl Acetate, stabilised (see **Appendix 2b**) is a combustible material with a flashpoint of 8°C. In the event of fire, use dry chemical, $CO_2$, water spray or foam. Extremely flammable liquid. In a fire or if heated, a pressure increase will occur and the contain may burst, with risk of subsequent explosion. The vapor/ gas is heavier than air and will spread along the ground. This cargo, stowed and segregated as per the IMDG Code, could be carried on deck or below deck. (See **figures 34 and 35** – outlined with lighter blue square).

1.9.10.4 Perfumery products (see **Appendix 2b**) is a highly flammable material with a flashpoint of about 17°C. In the event of fire, use dry chemical, $CO_2$, alcohol based resistant foam or foam. In a fire, the release of carbon monoxide, carbon dioxide and unburned hydrocarbons (smoke). Nitrous oxides may form explosive mixtures with air. The vapor/ gas is heavier than air and will spread along the ground. This cargo, stowed and segregated as per the IMDG Code, could be carried on deck or below deck. (See **figures 34 and 35** – outlined with green square).

1.9.10.5 Caustic Soda (see **Appendix 2a**), on the other hand, is not a combustible material, however if it is involved in a fire, suitable extinguishing agents include fine water spray, $CO_2$, DCP or foam. Caustic Soda[155] is corrosive to metals

[155] Caustic Soda will react adversely with Nitric Acid and generate water as a by-product. *Source*: Chemist of the Regulator of the Port of Singapore.

and reacts violently with acids. Physical exposure of Caustic Soda to moisture should be avoided as it causes an exothermic[156] reaction on dilution with water. This cargo, stowed and segregated as per the IMDG Code could be carried on deck or below deck. (See **figures 34 and 35** – outlined with yellow square).

1.9.10.6 Among others, some of the non-DG containers (see **figures 34 and 35**) loaded in the cargo hold and on deck in the vicinity of container *FSCU7712264* at the time of the occurrence were:

- Nine twenty-footer containers containing Prilled Urea (About 208 metric tonnes) not classed as Hazardous for transport under IMO, IATA and DOT. Urea is incompatible with sources of ignition and oxidising agents, Urea has melting point at 133°C and burn in presence of heat. Products decomposes upon heating and emits toxic fumes such as ammonia, oxides or nitrogen, cyanuric acid, cyanic acid, biuret, carbon dioxide.
- Four forty-footer containers containing wagons and vehicles inside cargo hold #2 (About 34 metric tonnes) and two twenty-footer containers on deck containing vehicles (about 8 metric tonnes).

1.9.11 Information about container *GESU2837027*

1.9.11.1 On 3 May 2021, the two containers[157] (*FSCU7712264* and *GESU2837027*) arrived at the Port of Jebel Ali and were stowed at a yard awaiting the arrival of XM. On the same day, container *GESU2837027* was found to be leaking by the terminal operator[158] who then informed the Shipper that container *GESU2837027* needed to be inspected[159]. Container *GESU2837027* was then transported to the Leaking Container Area.

1.9.11.2 According to the Operator, there was no requirement for the terminal operator to inform them about the leak from container *GESU283702*. This understanding was echoed by the terminal operator, i.e. the terminal operator would only inform the Shipper.

[156] Chemical reaction that produces and releases heat.
[157] The two containers were transhipment cargo from another ship the Ronika 11009.
[158] Inspects all containers while discharging, loading or while stowed at the container yard.
[159] According to the Shipper, the guidelines pertaining to inspection of containers at the yard were under the purview of terminal operator.

1.9.11.3 The investigation team gathered that at the instructions of the Shipper, a third-party inspection of container *GESU2837027* was carried out on 10 May 2021. A summary of the inspection findings is captured below:

*"Container was continuously leaking at the time of inspection. Holes were observed on side wall panels and end wall panels. Container door could not be opened due to continuous emissions of vapors from container and to avoid any escalation of vapor emission. Approved hazmat company to eliminate the source of leak prior further transportation of container from leaking container area."*

1.9.11.4 The other container, container *FSCU7712264* was then loaded[160] onboard XP when the ship called Jebel Ali on 10 May 2021.

1.9.11.5 As a result of the first inspection which was only around the external structure of container *GESU2837027*, a follow-up inspection and reworking[161] was recommended by the inspecting officer. The follow-up inspection and reworking started on 22 May 2021 and was completed on 23 May 2021. The Operator and the Company were not aware of the condition of container *GESU2837027* and its contents until 23 May 2021 (see **figure 38**). The inspection of container *GESU2837027* primarily revealed –

- The protective cages[162] (bands) of the IBCs were badly corroded all around;
- Some IBCs stowed below had their integrity compromised resulting in those stacked on top of them "tilted"; and
- The IBCs were discoloured and look old.

[160] From the time the container arrived the yard to the time of loading onboard XP, there were no reports of any leak.
[161] Reworking involves transferring of the Nitric Acid from damaged IBCs to new IBCs, and thereafter, stuffing the IBCs back into an empty container (since the leaked container *GESU2837027* was reportedly badly damaged).
[162] To provide structural support and additional strength for stacking.

Figure 38 - Condition before reworking - *Source:* The Company

1.9.11.6 The inspection report further indicated that due to the powerful oxidising property of Nitric Acid and the ambient temperature conditions, the acid caused a fire with the combustible material inside the container and damaged the container.

1.9.11.7 The Operator informed the investigation team that after the reworking of container *GESU2837027*, the Shipper tried to load the reworked container[163] onboard XM, but the shipment was rejected by the Operator, citing safety concerns.

1.9.12 The investigation team noted that one Packing List (see **table 18**) for both consignments of containers *FSCU7712264* and *GESU2837027* was used, which indicated that 36 IBCs were consigned. The Packing List did not indicate

[163] New container number WSCU8592772.

the date of manufacture of the IBCs. The Operator further confirmed that their booking process for accepting Nitric Acid did not include the date of manufacture of IBCs.

| Place of Loading: | Final destination: | Place of Discharge: | |
|---|---|---|---|
| JEBEL ALI - UAE | [redacted] | [redacted] | |
| **Description of Goods** | | **Quantity (MT)** | **Remarks** |
| **Nitric Acid**<br>HS Code:28080000 | | 50.00 | **TOTAL GROSS WEIGHT:**<br>52,460 KGS |
| **Total No of IBC:** | 36 IBC Tank | | **NET WEIGHT:**<br>50,000 KGS |
| **Total Gross weight:** | 52,460 KG | | |
| **Total Net Weight:** | 50,000 KG | | |

Table 18 – Packing List – *Source*: The Company

1.9.13 In its interaction with the investigation team, the Operator confirmed that the Terms of Acceptance of DG cargo for the Shipper, required that all DG containers and commodities within, must be stowed, secured, packed, labelled, and stated in the manifest as per current requirements of the IMDG Code, its Special Provisions and those within the Code of Practice for Packing of Cargo Transport Units (CTU Code).

1.9.14 Under the CTU Code, the Shipper is responsible for any deficiency of the CTU that is a result of poor packing and securing. The Code further requires that DG cargo to be secured in a manner unlikely to damage the individual packages comprising the unit load. The materials used to bond a unit load together to be compatible with the substances unitised and retain their efficiency when exposed to moisture, extremes of temperature and sunlight.

1.9.15 The CTU Code further recognises that the Shipper should provide information about the cargo and the packing details to the Operator[164].

[164] The Operator upon receiving the information will then forward it to the Carrier i.e., the Company.

1.9.16 The CTU Code also states that a transport unit (container) which is leaking or deemed unsafe for further transport should not be loaded onto a means of transport (e.g. ship, trailer). Planning of packing should be conducted as early as possible and before packing actually commences. Planning should aim at producing either a tight stow, where all cargo packages are placed tightly within the boundaries of the side and front walls of the transport unit, or a secured stow, where packages do not fill the entire space and will therefore be secured within the boundaries of the transport unit by blocking and/or lashing.

1.9.17 IMDG Code 1.3.1.5 requires the following shore personnel (amongst others) to be trained in General awareness training, function specific training and safety training –

- personnel who classify DG;
- pack DG;
- prepare transport documents for DG; and
- accept DG for transport.

1.9.18 Chapter 4 of the IMDG Code contains information on B15 provisions, that is, IBCs shall be no more than two years from their date of manufacture. According to the Shipper, local government regulations (UAE in this case) relating to DG cargo, typically require one or two personnel from the Shipper to be trained (informally) on various functions contained in IMDG Code 1.3.1.5 relating to cargo classification, proper shipping names (Function 1), packaging, marking, labelling (Function 2), placard (Function 3), and transport documentation (Function 5), and related matters including general understanding of the matrix in IMDG 1.3.1.6 (see **table 19**).

| | Function | IMDG Code part/section | | | | | | | | | | | | | | | SOLAS chapter II-2/19 | Port byelaws | National transport regulations | CSC | CTU Code | Emergency response procedures | First aid measures | Safe handling procedures |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 2.0 | 3 | 4 | 5 | 6 | 6 | 7.1 | 7.2 | 7.3 | 7.4 | 7.5 | 7.6 | 7.7 | 7.8 | 7.9 | | | | | | | | |
| 1 | Classify | X | X | | X | | X | | | | | | | | | | | X | | | | | | | | |
| 2 | Pack | X | | X | X | X | X | X | | | X | X | | | | | | X | | | | | | X | X | X |
| 3 | Mark, label, placard | | | X | X | | X | | | | | | | | | | | | | | | | | | | |
| 4 | Load/unload cargo transport units | X | | X | X | X | X | | X | | X | X | | | | | | | | | | X | X | X | X | X |
| 5 | Prepare transport documents | X | | X | X | | X | | | | | | | | | | | X | | | | | | X | X | |
| 6 | Offer for transport | X | X | | X | X | X | X | | X | X | X | X | X | X | X | X | X | | X | X | X | X | X | X | |
| 7 | Accept for transport | X | X | | X | X | X | X | | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | |
| 8 | Handle in transport | X | | X | X | | X | | X | | | X | | | | | | | | X | X | X | | X | X | X |
| 9 | Prepare loading/ stowage plans | X | | X | X | X | X | | | X | X | X | X | X | X | X | X | X | X | X | | | | X | | |
| 10 | Load/unload from ships | X | X | | X | | X | | | | | X | | | X | | | X | | X | | X | X | X | X | X |
| 11 | Carry | X | | X | X | X | X | | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |

Table 19 - IMDG Code training matrix - *Source*: IMDG Code 2018 Edn. Vol 1

1.9.19 The Shipper added that their team had undergone informal training for IMDG compliance in accordance with local regulations. The Shipper confirmed that they did not have any information on the date of manufacture of the IBCs used in containers *FSCU7712264* and *GESU2837027*. The Shipper further confirmed that they were not aware of the provisions for IBCs (B15) for carriage.

1.10 Other cases of Nitric Acid leakage

1.10.1 The investigation team gathered information about handling of previous Nitric Acid leakage occurrences at the Port of Singapore. Although none of the cases reported involved IBCs, some cases are listed below (see **figures 39 – 41**).

Figure 39 - Case 1, fumes from leaking drums, and damaged drum (1 cm crack at the bottom of the drum) - *Source*: Regulator of the Port of Singapore

Figure 40 - Case 2, lower tier jerrican crushed and damaged (hairline crack at the bottom of the jerrican) - *Source*: Regulator of the Port of Singapore

Figure 41 - Case 3, lower tier jerrican crushed and damaged (1 cm crack at the bottom of the jerrican) - *Source*: Regulator of the Port of Singapore

1.10.2 Typically, handling of such leakage involved the use of tarpaulin (see **figure 42**) and flushing the leak with copious quantities of water. Inert absorbent pads were used to contain the acid residues.

Figure 42 - Use of tarpaulin to minimise the spread of the leak - *Source:* Regulator of the Port of Singapore

1.10.3 During the reworking, some recommendations were documented –

- To pack the drums and jerricans without the use of flammable material, such as, wooden pallets, also to minimise the risk of cuts (due to protruding nails from the wooden pallets);
- Minimise the use of plywood between tiers for weight distribution; and
- Lining of container with tarpaulin to contain any residue.

Figure 43 - Recommendations during reworking of Nitric Acid leakage - *Source*: Regulator of the Port of Singapore

1.10.4 The investigation team also noted that one of the cases involving Nitric Acid leaking from an ISO tank (see **figure 44**) was handled at the anchorage, which required the off-loading of the ISO tank onto a barge, and the use of copious quantities of water.

Figure 44 - Leaked ISO tank off-loaded onto a barge - *Source:* Regulator of the Port of Singapore

1.11 Meteorological Condition

1.11.1 XP's AIS plots overlayed with meteorological condition that the ship encountered on passage from Hamad to Hazira were extracted by the investigation team[165].

1.11.2 XP's track after departing the Gulf of Oman, crossed the Arabian Sea on a Southeast heading towards the Port of Hazira, India. During the Southeast passage, XP predominantly encountered South-westerly wind and seas of about 10 to 15 knots on the starboard beam (see **figure 45**).

[165] The Marine Traffic provides satellite AIS data/ plots for ship tracking.

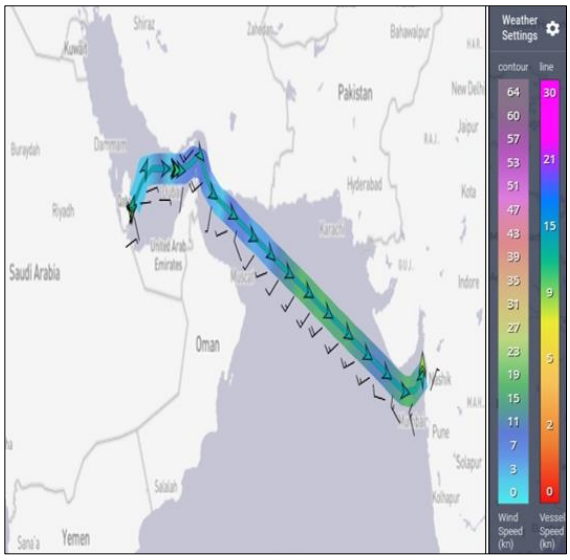



Figure 45 – XP's route and meteorological condition experienced on passage from Hamad, Qatar to Hazira, India - *Source*: Marine Traffic

1.11.3 **Figure 46** shows XP's track from the Port of Hazira to the Port of Colombo, Sri Lanka, while avoiding the cyclone Tauktae.

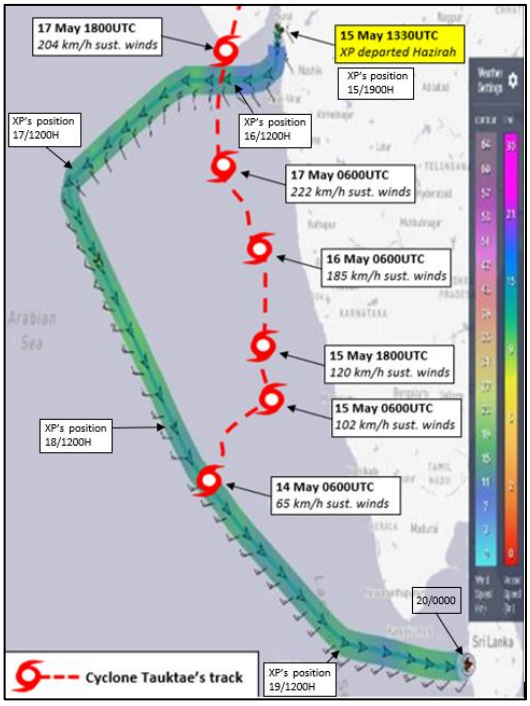


Figure 46 – Cyclone Tauktae's track[166] overlayed onto XP's AIS plots - *Source:* Marine Traffic (*annotation by TSIB - Not to scale*)

1.11.4 **Figure 47** shows satellite image produced by NASA earth observatory a few hours before cyclone Tauktae made landfall.

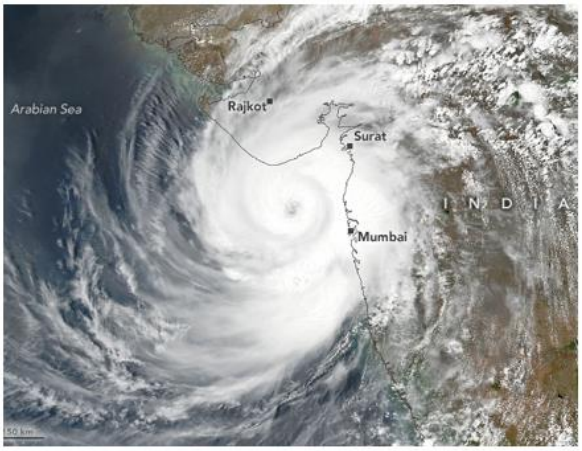



Figure 47 - Satellite image by NASA earth observatory showing the cyclone

1.12 Fire Forensic Investigation report

1.12.1 An independent Fire Forensic Expert (FFE) was engaged by the Company to determine the origin and probable cause of fire. At the time of publishing this investigation report, the report of the FFE was not made available to the investigation team.

1.12.2 The investigation team noted that on 27 June 2021 four samples provided by the FFE were tested by an independent testing laboratory. These samples had reportedly been obtained from container *GESU28370272* to establish the actual strength (concentration) of Nitric Acid packed in that container to further assess how it should have been packed. The results showed that the concentration of Nitric Acid in those samples were around 68-69wt%, indicating that the Nitric Acid being shipped in container *GESU2837027* was between 65 and 70%.

[166] Tauktae's track as reported from Global Disaster Alert and Coordination System (GDAC).

1.12.3 According to some information provided by the FFE, the Nitric Acid in container *GESU2837027* was improperly stowed. The metal bands used for the IBCs were also corroded, causing them to distort and fall over within the container and resulting in the leak of Nitric Acid. The FFE expressed the probability that the Nitric Acid from container *FSCU7712264* could also have leaked in a similar manner, i.e. like the condition in container *GESU2837027*, the powerful oxidising property of the Nitric Acid in ambient temperature conditions may have caused a fire with the combustible material inside the container which resulted in damaging the container and possibly the floorboard and subsequently igniting the rubber seals on container doors.

1.12.4 The cause of "explosions" as reported by the crew, were not identified by the FFE, it was noted that within bay 10(11) and directly below the leaking container *FSCU7712264*, were five containers of Urea. There were also four additional containers of Urea at bay 09.

1.12.5 According to the FFE, the decomposition of one or more of these Urea containers, either by way of thermal decomposition and/ or reaction with an alkaline solution may have given rise to the rapid generation of ammonia (which was also detected by salvors) and an exothermic reaction. It was also hypothesised that some of the resulting cloud of ammonia fumes may have made its way along the Under-deck passageway eventually.

1.13 Information from the Company

1.13.1 During its interactions with the investigation team, the Company shared the following timeline -

- On 21 May 2021, salvors were engaged under Lloyd's Open Form (LOF) conditions; and
- On the same day, MEPA issued an advisory[167] saying that the ship should be towed away from Sri Lankan waters.

1.13.2 Salvors tried but were not able to turn XP's stern to the wind, which would have enabled the fire and smoke which started at cargo hold #2, to be blown forward,

[167]A copy of this advisory was not made available to the investigation team.

away from the accommodation and engine room using the burnt area at cargo hold #2 as the fire break.

1.13.3 Despite the continuous firefighting operation by tugs in progress, the Special Casualty Representative[168] appointed under the LOF SCOPIC[169] reported that it was virtually impossible to get the ship in a safe condition given XP's existing location, which was away from more sheltered waters and subject to the effect of the monsoon.

1.13.4 In addition, the Company held the view, that XP was at an anchorage of about 12 meters in depth and the anchor position was towards the windward side and if XP sank at its existing location' all resultant debris and pollution would be pushed by the prevailing monsoon conditions onto the coastline. Furthermore, it would entail extensive wreck removal and pollution clean-up on a shore that were to be constantly exposed to heavy swell for the next few months. It would have been thus desirable to move XP to deeper waters away from the Sri Lankan coast.

1.13.5 Repeated requests by the Company to the salvors for XP to be towed away from the Sri Lankan waters was not heeded to. These requests were independent to the MEPA advisory. The salvors made a towing connection to XP on 2 June 2021 after the ship was slowly taking in water and increasing in drafts. When they eventually attempted the tow, XP could not be moved as the ship's stern was touching the seabed.

1.14 Information from the salvors

1.14.1 The salvors' contractual obligations under the LOF were to use their best endeavours to save the ship and to take the ship to a place of safety if needed, and while performing such services, to prevent or minimise damage to the environment.

1.14.2 The investigation team obtained the following timeline from the salvors -

- 21 May 2021, LOF contract signed and salvors were underway to

[168] Appointed on the 29 May 2021.
[169] Special Compensation P&I Club Clause.

Colombo on 22 May 2021;

- 23 May 2021, salvors went onboard tug Posh Teal and were transferred to XP; and
- Firefighting and salvage equipment arrived Colombo on a chartered plane from the Netherlands on 24 May 2021.

1.14.3 The salvors dispatched a tug from Singapore with additional firefighting equipment including, foam, Dyneema ropes, cutting equipment, pumps, hoses, power packs and oil spill response equipment. Although the salvors sourced and managed to get tug “Posh Teal” with the towing arrangement, the salvors could not find any suitable salvage pump in Sri Lanka and encountered difficulties in logistic operations due to the Covid-19 protocols prevailing at the time.

1.14.4 On arriving XP, noting the ship on fire, the immediate priority was to extinguish and/ or contain the fire and prevent pollutants from entering the environment by keeping them contained within the hull.

1.14.5 Consideration was made by the salvors to tow the ship’s stern to the wind to prevent the fire spreading aft. While waiting for the tow wire and pennant to be ready, the Salvage Master used a towing arrangement with mooring ropes to bring the ship’s beam, if not the stern, to the wind. Several hours later, the mooring ropes broke due to shock loading and wear and tear under the prevailing weather conditions.

1.14.6 According to the salvors, they had limited tug resources on site and had to prioritise between towing and firefighting. The more powerful tug such as “Posh Teal” had to be used for both towing and firefighting.

1.14.7 On the morning of 25 May 2021, there was an explosion forcing salvors to abandon XP with the crew, leaving their salvage/ firefighting equipment onboard. A tow could not be re-established, and the fire continued to burn.

1.14.8 The salvors’ priority continued to be firefighting to contain the fire. From 26 May till 1 June 2021, no towing connection was established as it was not safe to board the ship due to adverse sea and weather conditions, prevalent smoke, toxic gases, instability of containers, risk of further explosions, requirement for

breathing apparatus to be worn and the risks in disembarking.

1.14.9 After abandoning ship, the salvors underwent medical checks ashore and waited for the arrival of new PPE, chemical firefighting suits and gas measuring devices etc. to ensure the team's safety before they could board XP again. The safety equipment arrived on 31 May 2021.

1.14.10 On 1 June 2021, the salvors received instructions from the MEPA to move XP West of its present location to minimise damage to the environment due to a possible oil spill and hazardous substances being discharged. According to the salvors, due to the SW monsoon conditions and swell, there were no sheltered locations West of Sri Lanka, other than the Port of Colombo, which was the closest, while the Ports in Hambantota and Trincomalee were potential candidates for place of refuge.

1.14.11 The passage to either of those Ports (Hambantota and Trincomalee) would have required passing through the SW Monsoon and rough weather at a relatively close distance to the Sri Lankan coastline. According to the salvors, permission sought from the relevant authorities to enter Colombo or Hambantota was not granted.

1.14.12 The salvors further held the view that towage to deep water would have been contrary to their contractual obligations under LOF.

1.14.13 The Salvage Master explored with the Master of tug "Posh Teal" about towing XP using the anchor chain. However, this was not possible as there was no wide body shackle (250T) available to connect tug Posh Teal's grapnel to XP's anchor chain. The salvors also shared the concerns of tug "Posh Teal's" Master on being able to safely conduct such an operation. A towing connection was made at the bow on 2 June 2021 by which time the XP was sitting on the seabed.

1.14.14 The salvors also added that prior to XP sitting on the seabed, based on her draft readings (being unable to board the ship), there were no immediate concerns regarding the buoyancy of the ship.

1.15 Discharge of plastics pellets into the sea

1.15.1 XP was noted to be carrying several containers[170] of epoxy resin plastics. The investigation team noted from the IMO[171] that "11,000 metric tonnes of plastic pellets[172] were spilled off the shore of Colombo". The report further cited the ensuing pollution brought on by the fire and subsequent sinking of XP, caused an overwhelming economic, social and environmental impact.

1.15.2 Additional information from the UN report highlighted that epoxy resin is harmful to the environment, and "it is toxic to aquatic life and can have long lasting effects on marine fauna."

1.15.3 In its paper[173] to the IMO's MEPC, Sri Lanka highlighted the hazardous nature of plastic pellets and the need to establish international guidelines and requirements for loading, unloading, packaging, and emergency response protocols, with clear labelling of containers carrying pellets, and improved stowage instructions.

1.16 Jettisoning of container

1.16.1 MARPOL Annex III[174]/7 states that jettisoning of harmful substances carried in packaged form shall be prohibited, except where necessary for the purpose of securing the safety of the ship or saving life at sea.

1.16.2 Recognising that jettisoning containers at sea requires a detailed risk assessment and a thorough procedure for it to be carried out safely, the investigation team considered the option for the Master to jettison container *FSCU7712264* at sea, especially when efforts to offload it in Hamad and Hazira

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[170] "9,700 metric tonnes loaded in 349 containers" per UN Environmental Advisory Mission report.

[171] www.imo.org – Marine Environment Protection Committee (MEPC) 77, 22-26 November 2021.

[172] Microplastics (nurdles or plastic pellets measuring less than five millimeters. 'Nurdle' refers to a very small pellet of plastic which serves as raw material in the manufacture of plastic products. *Source:* UN Environmental Advisory Mission report.

[173] MEPC 77/8/3 – FOLLOW-UP WORK EMANATING FROM THE ACTION PLAN TO ADDRESS MARINE PLASTIC LITTER FROM SHIPS (Comments on document MEPC 75/8/3**). Submitted by Sri Lanka.

**MEPC 75/8/3 – FOLLOW-UP WORK EMANATING FROM THE ACTION PLAN TO ADDRESS MARINE PLASTIC LITTER FROM SHIPS (Report of the Correspondence Group on Development of a Strategy to Address Marine Plastic Litter from Ships). Submitted by Singapore.

[174] Annex III of the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (MARPOL), deals with the prevention of pollution by harmful substances carried by sea in packaged form.

were unsuccessful. In its interaction with the Company, the investigation team gathered that the cargo crane onboard XP was not provided with spreaders and associated wire slings for such a jettisoning to take place.

1.17 Place of Refuge (POR)[175]

1.17.1 The investigation team gathered that the POR was not considered[176] when the offloading of the leaking container was unsuccessful at the Port of Hamad or Hazira.

1.17.2 The investigation team further established that discussions were held between the SLPA and stakeholders (the Company and salvors) concerning potential POR on 29 May 2021.

1.17.3 On 31 May 2021, authorities from the Sri Lankan Navy and port Authorities were in discussion of having Hambantota port (in Sri Lanka) to serve as POR for XP but there reportedly was no outcome[177] from the discussion.

1.17.4 The action of the coastal State does not prevent the Company or its representative from being called upon to take steps with a view to arranging for the ship in need of assistance to proceed to a POR. As a rule, if the POR is a port, a security in favour of the port will be required to guarantee payment of all expenses which may be incurred in connection with its operations, such as: measures to safeguard the operation, port dues, pilotage, towage, mooring operations, miscellaneous expenses.

1.17.5 According to IMO Res. A. 949(23), under international law, a coastal State may require the master or Company to take appropriate action within a prescribed time limit with a view to halting a threat of danger. In cases of failure or urgency,

[175] Place of refuge means a place where a ship in need of assistance can take action to enable it to stabilize its condition and reduce the hazards to navigation, and to protect human life and the environment. *Source*: GUIDELINES ON PLACES OF REFUGE FOR SHIPS IN NEED OF ASSISTANCE - IMO Res. A. 949(23). A review of the guidelines was approved by IMO for its subsequent adoption by the 33rd session of the Assembly in 4Q 2023.

[176] Ship in need of assistance means a ship in a situation, apart from one requiring rescue of persons onboard, that could give rise to loss of the ship or an environmental or navigational hazard. Masters should, where necessary with the assistance of the company and/or the salvor, identify the reasons for his/her ship's need of assistance. *Source*: GUIDELINES ON PLACES OF REFUGE FOR SHIPS IN NEED OF ASSISTANCE - IMO Res. A 949(23).

[177] When permission to access a POR is requested, there is no obligation for the coastal State to grant it, but the coastal State should weigh all the factors and risks in a balanced manner and give shelter whenever reasonably possible. *Source* IMO Resolution A.949(23).

the coastal State can exercise its authority in taking responsive action appropriate to the threat.

1.17.6 The Guidelines further stipulate that –

- coastal States establish procedures to address these issues, even if no established damage and/ or pollution has occurred and should, establish a Maritime Assistance Service (MAS) ;
- an inspection team designated by the coastal State should board the ship, when appropriate and if time allows, for the purpose of gathering evaluation data; and
- a comparison should be done between the risks involved if the ship remains at sea and the risks that it would pose to the place of refuge and its environment, covering for e.g. risk of pollution.

1.17.7 The investigation team was not able to determine the procedures in place in Sri Lanka to assess the balance between the advantage for the affected ship and the environment resulting from bringing the ship into any port in Sri Lanka and the risk to the environment resulting from that ship being near the coast.

## 2 ANALYSIS

### 2.1 Probabilities on the cause of the occurrence

2.1.1 As the evidence onboard XP were lost due to the fire and the subsequent sinking of the ship, the investigation team predominantly relied on information obtained from the crew of XP, the Company, the Shipper, the Operator and the salvors. The investigation team also sought opinions of the HSA, the SCDF and Regulator's Port Chemist to have a better understanding of the properties of Nitric Acid and other cargo in the vicinity of container *FSCU7712264*, in addition to various documents and records, to establish the probabilities outlined in the Analysis.

2.1.2 The investigation team tried to establish and consider the following probabilities which could have contributed to the events:

- Mis-declared consignment - The Company did not find any evidence (after occurrence) during its verification exercise. The evidence available to the investigation team also showed that the cargo stowed onboard XP followed the relevant rules of stowage and segregation as per the IMDG code.
- Electrical source - According to EO the condition of the electrical system onboard XP was normal and in accordance with the Company's requirement for reefer containers (ref **para 1.1.8.7**). There was no indication of any earthing or insulation fault before the onset of the fire alarm. It is unlikely that an electrical source was the trigger for the fire onboard XP.

2.1.3 The investigation looked into the following:

- Probable cause of the leak of Nitric Acid and probable cause of fire;
- Packing requirements of Nitric Acid and Shipper's responsibility;
- Onboard actions to manage container *FSCU7712264* leakage;
- Efforts and challenges in discharging container *FSCU7712264*;
- Response of the shipboard crew for firefighting;

- Response by the shoreside personnel; and
- Development and spread of fire.

2.1.4 The investigation team examined the following areas although they did not contribute directly to the occurrence:

- Abandon ship;
- Declaration of Nitric Acid and its concentration; and
- Communication barriers and maritime English.

2.2 Probable cause of the Nitric Acid leak and probable cause of fire

2.2.1 Containers (*FSCU7712264* and *GESU2837027*) arrived at the Port of Jebel Ali on 3 May 2021 and container *GESU2837027* was found leaking on the same day which resulted in it being segregated for reworking. Container *FSCU7712264* was loaded onboard XP. On 22 May 2021 (after the fire onboard XP), inspection of container *GESU2837027* revealed that the protective bands of the IBCs used for the storage of Nitric Acid were badly corroded (see **figure 38**).

2.2.2 It is highly probable that the condition of the IBCs within container *FSCU7712264* was similar to those in container *GESU2837027* as they were stacked and packed by the same Exporter and sent to the Shipper. As opined by the FFE, the corrosion of the bands used to secure the IBCs could have been weakened and caused the top stacked IBCs to fall over, resulted in damages to the IBCs and the subsequent leaking of Nitric Acid within the container.

2.2.3 The leak from container *FSCU7712264* was reportedly ceased prior to arriving at the Port of Hazira. The investigation team recognised the Master's decision to go further west after departing the Port of Hazira, to minimise the effect on XP's passage towards Colombo.

2.2.4 Due to the effect of the cyclone causing the ship to roll and pitch, the deck crew were not given any deck work due to the bad weather.

2.2.5 This rolling and pitching of the ship had likely caused the leak of Nitric Acid from

the IBCs inside container *FSCU7712264* to resume, which had already been compromised during the previous legs of the voyage, i.e. from Hamad to Hazira. The evolution of orange/ brown smoke as reported by the Master on 19 May 2021 and the falling of IBCs inside the containers could be heard (see **para 1.1.7.10**) is indicative of some reactions had commenced 10 days prior, i.e., a possible reaction of Nitric Acid with the metal construction of the container.

2.2.6 It is likely that the accumulated Nitric Acid after penetrating through container *FSCU7712264* floorboard made its way onto the hatch covers and main deck and entered cargo hold #2 through the gaps in the hatch cover panels.

2.2.7 The investigation team noted that there was no washing of the Nitric Acid with copious water for the effluent to be flushed to the bilge well and then the diluted Nitric Acid to be pumped overboard, as had been done in the earlier stages from Hamad to Hazira. This increased the probability of concentrated Nitric Acid to accumulate in the vicinity of the cargo hold.

2.2.8 In this case, although the weather was not conducive to continuously monitor the leak from container *FSCU7712264*, where DG cargo is found leaking, steps to monitor the leak should be taken so that appropriate measures to mitigate the risk could be implemented.

2.2.9 Nitric Acid and rubber can cause exothermic reaction (see **para 1.9.9.1~1.9.9.6**). Correlating the observation of the CE and A-2E (see **para 1.1.8.22**) during the day, it is highly probable that the Nitric Acid had triggered a series of small fires when it came in contact with the rubber seals on the container doors. It is probable that the fire noted by the CE and A-2E may have been in, or in the vicinity of the containers loaded at bays 100112 and 100212 which contained Methanol.

2.2.10 When the CE and A-2E saw the small fires (which were in the middle top tiers inside the cargo hold), they were unable to extinguish them using a portable $CO_2$ extinguisher. These small fires likely then developed into large fires. It is likely that the A-2E was not familiar with the location of the DCP fire extinguisher on deck and went to the ECR to get one.

2.3 Packing requirements of Nitric Acid and Shipper's responsibility

2.3.1 According to B15 provisions of the IMDG Code, the IBC intended for the carriage of Nitric Acid (55% concentration or more) shall be no more than two years from their date of manufacture. There is no evidence to indicate that the date of manufacture of the IBCs for container *FSCU7712264* was known to any of the parties involved in the cargo booking process, e.g. the Shipper or the Operator. In all likelihood, considering the condition of the IBCs noted during the inspection of the *GESU2837027* (see **figure 38**), the IBCs used for container *FSCU7712264*, were probably more than two years old.

2.3.2 The investigation team noted that the Shipper also did not have measures in place to check the carriage condition of the IBCs before accepting the shipment. It thus appeared that the Shipper was not aware of the condition of the IBCs in container *FSCU7712264* when the cargo was received for shipment from the Exporter.

2.3.3 It would have been prudent for the Shipper to have procedures to ensure that the obligations under the CTU Code and the IMDG Code were fulfilled, such as ensuring that the IBCs were securely stowed (protective bands of the IBCs in good condition) in the container and the IBCs used for the shipment of Nitric Acid to be in accordance with the requirements of the B15 provisions of the IMDG Code.

2.3.4 Noting that the booking process does not require the verification of the condition of the IBCs inside the container and the acceptance of the booking is based on good faith, it is thus highly likely that the Operator was also unaware of the condition of the IBCs at the time of accepting the booking for the voyage as communicated by the Shipper.

2.3.5 The investigation team noted that it may not be practical for the Operator to inspect/ verify the contents of every DG container before acceptance of a booking. Nevertheless, this occurrence highlighted that such a verification process is important for the safety of the crew and the ship.

2.3.6 With the use of technology, such verification can be done at the time the cargo is (in this case the Nitric Acid being stored in the IBCs) loaded in the shipping container. Photographs of the IBCs used, together with the certificates attesting

the date of manufacture of the IBCs, and the condition of the protective caging, can be taken at the time of packing and be provided to the Operator for a better level of assurance. Such documentation can follow the shipment right from the beginning till the end of the voyage and doing so would allow proper verification by the stakeholders to ensure that DG within containers are packed, labelled, stowed, and secured as per the requirements of the IMDG code.

2.3.7 The investigation team also noted that container *GESU2837027,* which was on the same Packing List as container *FSCU7712264,* was found leaking at the Port of Jebel Ali on 3 May 2021. Although container *GESU2837027* was moved to the working yard thereafter, the follow-up detailed inspection only took place on 22 May 2021.

2.3.8 It would have been prudent for the Shipper to arrange for an early detailed inspection of container *GESU2837027* so that the condition of the Nitric Acid packaging in container *FSCU7712264* could also be verified before being loaded for the next voyage. Had such an inspection been done earlier, the probability of container *FSCU7712264* to be loaded on XP would be low as the detailed inspection of *GESU2837027* showed a poor condition of the IBCs.

2.3.9 The Company opined that the Shipper should have initiated a check on container *FSCU7712264* to prevent it from being loaded, upon being aware of the condition of container *GESU2837027*. While this may be an ideal and desirable action, the investigation team noted that this shipment had only two containers by the same Exporter. There may be a situation where numerous containers are a part of the same shipment and expecting the Shipper to initiate a check on all containers based on a leak detected in one container may be impractical.

2.3.10 Nevertheless, the investigation team held the view that after being informed of the leaking container *FSCU7712264*, the Shipper should have taken appropriate steps to inform the Operator of the leak detected in container *GESU2837027*, so that such critical information could have assisted in expedited efforts to offload container *FSCU7712264* from XP.

2.3.11 It also appeared that the Shipper relied on the Exporter’s declaration of the DG Class and was not aware of the subsidiary risk of Nitric Acid in container

*FSCU7712264.*

2.3.12 The supply chain is a complex operation and individual modes of transport may have defined terms for stakeholders which are not consistent with other modes of transport (*Source*: CTU Code). In cargo carriage, the Shipper is expected to ensure the shipment is safe for the voyage, i.e. in good condition, cargo-worthy and free from any damage.

2.3.13 It appeared that the provisions of the CTU Code had likely not been taken into consideration when preparing the containers *FSCU7712264* and *GESU2837027* for transport. The occurrence reiterated the importance of ensuring compliance with requirements for safe carriage of cargo so as to prevent reactive responses in the downstream logistical chain, which may pose challenges to be resolved timely.

2.4 Onboard actions to manage container *FSCU7712264* leakage

2.4.1 When the leak was discovered by the ship's crew from container *FSCU7712264,* the Master, in his communication with the Operator noted that the container had about 29 metric tonnes of Nitric Acid. The Master's actions to alert the relevant shore personnel about the leak were in accordance with the Company' SMS.

2.4.2 Container *FSCU7712264* had placards showing IMDG Class 8 and Class 5.1 cargo. Although the deck crew noted the pungent smell and the yellowish-green liquid which had bubbled and peeled the hatch cover paint in the vicinity of container *FSCU7712264*, none of the deck crew were aware of the contents of the container. On being notified of the leak by the 3O, the CO arranged for sawdust to manage the leak, and subsequent rinsing the area with seawater.

2.4.3 The investigation team noted that the MSDS (generic) for Nitric Acid does not mention the use of sawdust for containing a spill/ leak, instead, inert absorbent pads were supposed to be used to contain the acid residues. The EmS Guide on Class 5.1 DG cargo states that "these substances, while in themselves not necessarily combustible, may cause the combustion of other material (e.g., sawdust or paper) or contribute to the fire leading to an explosion.

2.4.4 While it could not be established with certainty that the presence of sawdust

contributed to the development of a fire, a check on the EmS Guide could have prompted a more appropriate response, i.e. use of inert absorbent pads (available in the SOPEP kit onboard) as an initial response in managing the leak in the initial stages, instead of using sawdust, which is organic and susceptible to combustion.

2.4.5 The EmS Guide on Class 8 DG cargo states corrosive vapours are highly toxic, often lethal by destroying lung tissue. The delayed response of the deck officers and crew to ascertain the nature of the leaking cargo and potential risks, reflected low level of safety awareness, and the crew were not reminded to don suitable protective clothing to ensure personal safety.

2.5 Efforts and challenges in discharging container *FSCU7712264*

2.5.1 The leak of Nitric Acid from container *FSCU7712264* was first discovered on 11 May 2021, i.e. a day after XP departed Port of Jebel Ali where this container was loaded onboard XP.

2.5.2 Management of such a leak typically demands extensive reworking to be done ashore which requires the assistance of shore services (see **para 1.10.1 – 1.10.4**). Such leak management onboard is limited to flushing the leak residue with copious amounts of water.

2.5.3 From the various correspondence since the leak was discovered, the investigation team noted that the Master had expressed concerns regarding the leaking container. Consequently, several attempts were made to offload container *FSCU7712264* and be reworked to make it seaworthy for a subsequent voyage, from the time it was found leaking till the XP's arrival at Colombo on 19 May 2021.

2.5.4 However, container *FSCU7712264* was not discharged at either the Port of Hamad or Hazira. At the Port of Hamad, the reasons cited were insufficient information provided to facilitate the offloading such as arrangement of relevant tanks (not provided at the time of the request), lack of protective equipment to handle the leak as well as the Port of Hamad not being the port of discharge and additional approval being needed from the Ministry of Municipality and Environment. The attempts to offload container *FSCU7712264* at the Port of Hamad were further compromised by the Ramadan holidays, considering the

ship's scheduled departure.

2.5.5 When the offloading of container *FSCU7712264* was not possible at the Port of Hamad, the Master and the Company did not consider returning to the Port of Jebel Ali to offload container *FSCU7712264.* The Operator, however initiated correspondence prior the departure from Port of Hamad, i.e. four days before arrival at the Port of Hazira, in cooperation with the Shipper to attempt to offload container *FSCU7712264* at the Port of Hazira.

2.5.6 Despite the timely requests, the reasons cited by the agents at the Port of Hazira were that the terminal did not have the capability to handle a leaking DG container (which had ceased prior arrival at the Port of Hazira), as well as the possibility of damage to the terminal property due to the leak.

2.5.7 The investigation team further noted that both Ports cited that as container *FSCU7712264* was not planned for discharge at their locations, approval to permit its offloading was a complex process. The investigation team also noted the Company's intention to offload container *FSCU7712264* at the Port of Colombo, after the two unsuccessful attempts to offload it at the previous ports.

2.5.8 The investigation team deemed that the compromised DG container posed a risk to the safety of the crew and the ship. Although the leak had initially ceased, it likely worsened after departing the Port of Hazira due to the rolling and pitching.

2.5.9 It is unfortunate that there were several missed opportunities to offload container *FSCU7712264.* This may have been a combination of the following – the inability of the ports where XP called to accept the leaking container due to various reasons cited, such as insufficient time to process the offloading and potential damage to the port facility due to the corrosive nature of the cargo.

2.5.10 Considering that the leak of Nitric Acid could pose a risk to a ship which has limited capabilities in dealing with a leak and a consequent fire, the occurrence demonstrated that it is highly desirable that the Company and the port authorities worked closely for the immediate offloading of container *FSCU7712264,* when such a request was made.

2.6 Response of the shipboard crew for firefighting

2.6.1 Release of $CO_2$

2.6.1.1 Prior to the release of the $CO_2$, the Master arranged for a headcount on two occasions to ensure the safety of the crew. The A-CO, after noting that the port side natural ventilation flaps for cargo hold #2 had been fully closed by the ASDs, had assumed that the starboard side natural ventilation flaps also been closed when the report from the A-2O was received, and updated the Master that all the ventilation flaps had been closed. This was not the case as some ventilation flaps at the starboard side remained open as the crew were not able to reach them due to heavy smoke. The ventilation flaps that remained open, coupled with a partially sealed cargo hold, had reduced the effectiveness of the $CO_2$ in extinguishing the fire in cargo hold #2.

2.6.1.2 Per the $CO_2$ operating instructions, based on the loading condition of about 67%~100% in cargo hold #2, the number of $CO_2$ bottles to be discharged should be 57.

2.6.1.3 However, the loading condition of cargo hold #2 was not verified by the crew to determine the appropriate quantity of $CO_2$ for the discharge. Instead, all the $CO_2$ bottles onboard XP were exhausted in one release to fight the fire inside the cargo hold.

2.6.1.4 While it is understandable that the Master may have been pre-occupied with the various responsibilities to manage the emergency, before releasing the $CO_2$, a check by the CE and A-2E with the other deck officers, specifically the CO and the A-CO, on the loading condition of the cargo hold #2 could have been done before releasing the $CO_2$. Such a verification would have saved the $CO_2$ to be used for two more times.

2.6.1.5 Although the CE had been onboard for a longer duration, and being responsible for the fixed $CO_2$ system, reasons for this verification not done by the CE could not be established. The A-2E who was present with the CE also did not query the release procedure.

2.6.1.6 It is probable that some elements of human factors[178] were at play given the rapid development of the fire and the response in the $CO_2$ Room such as divided attention[179], loss of situational awareness[180] and the possibility of confirmation bias[181].

2.6.1.7 The investigation team also opined that in the absence of any SMS requirement that requires familiarisation with the fixed $CO_2$ system, it is likely that under the circumstances, the requirement to release the $CO_2$ based on cargo loading condition was not carried out.

2.6.2 Assignment of roles in emergency

2.6.2.1 The emergency onboard XP started from a container leaking Nitric Acid which evolved into a fire. To understand the command and control of this emergency, the investigation team reviewed the sample of the muster list provided by the Company, typically used on their fleet of ships. The crew of XP were likely on the same roles as the typical muster list.

2.6.2.2 For a fire on deck, as per the muster list, the Chief Officer (in this case the A-CO) was the leader of the Emergency team and the Second Engineer (in this case the A-2E), the leader of the Back Up team. As the leader of the Back Up team, the A-2E was to assist the A-CO for firefighting on deck, including closure of the ventilation flaps.

2.6.2.3 When the Master raised the general emergency alarm on 20 May 2021, the A-2E was asked by the CE to go to the $CO_2$ Room with him, which was not in accordance with the muster list, leaving the Back-Up team without a leader. And no instructions from the A-2E which resulted in the members of the Back-up team to be absent for closing the ventilation flaps and firefighting.

2.6.2.4 The A-CO assigned the closure of ventilation flaps to the A-2O, the leader of the Support team, whose primary responsibility was to provide first aid and to assist Back-Up team as required. This is likely because the A-CO was new onboard, and randomly allocated tasks to crew as the situation evolved. It is

[178] Human Factors for Transport Safety Investigators, 2019.
[181] Lack of cognitive resources necessary to manage multiple tasks, and the inability of an individual to be able to multi-task when required when too many things are going on.
[180] Factors leading to poor situational awareness include task overload, fatigue, and stress.
[181] The tendency for people to search for information that confirms an expectation.

probable that due to similar reasons the A-2O who was also new onboard, did not lead a team in a coordinated effort to close the ventilation flaps as the leader of the Back-up team in the absence of the A-2E.

2.6.2.5 When the two OS went to close the natural ventilation flaps of cargo hold #2 on the starboard side main deck passageway, they did not wear the SCBA set and fireman's outfit. It is likely that the smoke and heat in the vicinity had prevented them from approaching the flaps. Noting that the typical time (though not representative) to close a cluster of five flaps donning SCBA set and fireman's outfit was about 5 minutes, the investigation team held the view that donning the of SCBA set and fireman's outfit was a critical part of the response which had not been carried out.

2.6.2.6 The investigation team held the view that because a muster list contains duties and responsibilities assigned to each person, being new onboard, the A-CO and A-2O could have used the muster list as a guide to have a better command and control of the situation and subsequent task allocation.

2.6.2.7 Crew are trained, and are familiar, in performing their roles as assigned in the muster list, which provides a structured approach in tackling an emergency. Assigning roles to crew as per the muster list would obviate the need to supervise every task done by individual crew.

2.6.2.8 The investigation team observed that the off-signers were only utilised during the early stage of emergency i.e. assisting in boundary cooling. The investigation team also noted that the off-signers had handed over their duties and responsibilities prior to arriving Colombo. However, the investigation team opined that in an emergency, all resources should be utilised to tackle the situation effectively. Being onboard XP for a longer duration and familiar with the ship, the off-signers could have been assigned to any of the team and to assist the team leader accordingly.

2.6.2.9 It is highly probable that the command and control onboard XP during the fire emergency lacked coordination and all resources were not utilised effectively.

2.6.3 Use of SCBA set and fireman's outfit

2.6.3.1 The investigation team noted that although SCBA sets and fireman suits were brought to the gangway and kept aside, when the A-2E went to cargo hold #2 to check for signs of re-ignition with the two ASDs, neither of them wore SCBA sets. Although the A-2E reported to the Master that cargo hold #2 was full of smoke, and no fire was sighted, the accuracy of this report in the absence of a SCBA sets being used would be in doubt, i.e. there could have been fire inside cargo hold #2, which was not noticed.

2.6.3.2 In its interaction with the crew, there was no evidence shown to the investigation team that the SCBA sets were leaking as reported by the Master to the Company on 20 May 2021. However, none of the relevant personnel were able to give reasons why the SCBA sets were not used. The ship was new and had new equipment onboard since delivery.

2.6.3.3 Despite encountering toxic smoke and fumes during the entire time, and efforts were being made to respond to the emergency, the fireman's outfit was also not used, except by the A-2E.

2.6.3.4 To the investigation team's queries on the leak of SCBA sets, the Company confirmed that the leak was due to improper operation of the SCBA sets, which were later rectified by the crew. The Company further added, thereafter, the next day the SCBA sets were used throughout for firefighting operation.

2.6.3.5 The investigation team noted that the SCBA sets and fireman's outfits had been used during the fire drill on 16 May 2021 to satisfaction. In this regard, had the drill and training been carried out effectively, the crew would have been made aware of the mode setting for the SCBA sets.

2.6.3.6 Using the PPE like the SCBA sets and fireman's outfit, can help to provide for better firefighting efforts and aid in gathering more accurate information of the situation, in this case about cargo hold #2. It is thus crucial to ensure that the SCBA sets and fireman's outfits are used for their intended purpose.

2.6.3.7 With proper PPE donned in such emergency, the crew would be more confident in getting deeper into the cargo hold #2 and gathering more accurate information of the situation for a better decision making in consultation with the salvors on the next steps to respond to the emergency.

2.6.4 Ventilation flaps – Closing and their design.

2.6.4.1 For this voyage there were no reefer containers being carried in cargo hold #2. As such the ventilation flaps were not required to be open. The reasons for these flaps to remain open could not be established by the investigation team. Since the flaps were left open, this became an added task for the crew to close them in preparation for the release of $CO_2$.

2.6.4.2 The investigation team noted that the design of the ventilation flaps on XP were of a typical type found on most container ships. Closing them on XP required the use of an elevated step. A simulated closing of the ventilation flaps on XM by a crew putting on a SCBA set took an average time of about one minute per flap. Without using SCBA set, although the time taken was lesser, the cumulative time for closing all 36 flaps was about 20 minutes.

2.6.4.3 The presence of heat and smoke made it difficult for some of the ventilation flaps to be closed, especially without donning a fireman's outfit and an SCBA set. There was no evidence to suggest that the challenges in closing the ventilation flaps, with or without the SCBA set and fireman's outfit, had been taken into consideration when the task was assigned to the crew.

2.6.4.4 In considering a review of the design of the flaps, the investigation team assessed that remote means of closure of such ventilation flaps as identified in a similar investigation[182] should be considered by the industry, so that the crew are in a better position to manage such an emergency.

2.7 Response by the shoreside personnel

2.7.1 Shoreside and salvors' actions

2.7.1.1 The VDR could have provided the investigation team better insights into the communication between XP and the shore personnel as the emergency was unfolding. As the VDR data was not available to the investigation team, despite repeated requests made to the Coastal State, XP's crew accounts could not be corroborated. Based on XP's crew accounts, the Master and A-CO had

[182] Similar challenges were documented in the investigation into a fire involving the Maersk Honam (TSIB REF: MIB.MAI.CAS.035).

made multiple calls to Colombo Port Control requesting for urgent berthing when the smoke alarm was triggered. However, there was no response or advice on whether XP could be berthed earlier.

2.7.1.2 The investigation team's attempts to establish whether the Port of Colombo had provisions to accommodate XP's urgent berthing requests were unsuccessful.

2.7.1.3 The firemen dispatched by Colombo Port Control embarked XP on 20 May 2021 for an assessment of the situation onboard. Reasons for them not to don the chemical suits provided by the crew of XP could not be established. It is likely that the situation had deteriorated, which may have prompted them to discuss options ashore instead of making an assessment onboard.

2.7.1.4 When Colombo Port Control was advised that the ship had discharged[183] all of its $CO_2$ into cargo hold #2, and was dependent on seawater for firefighting, apart from sending the Navy ship with firemen onboard XP (which did not have any follow-up or advice subsequently) and to continue monitoring the temperature of cargo hold #2, there was no plan for XP to berth at the port.

2.7.1.5 The investigation team also noted that the instruction from the MEPA was to tow the ship away from the port, considering the pollution risk the ship posed, should she sink in-situ. This instruction appeared contrary to what was being hoped for by the salvors, which was to manage this incident by moving the vessel closer into port as doing so could be more effective for firefighting, compared to firefighting at anchorage where the prevailing weather conditions could pose more challenges.

2.7.1.6 The salvors boarded XP on 23 May 2021 and took over the firefighting command and control and were duly assisted by the Master and crew. From the time the salvors boarded the ship till XP was abandoned on 25 May, the salvors had limited time to assess the situation, inspect the condition and take steps to fight the fire with limited equipment.

2.7.1.7 The prevailing weather conditions at the anchorage were not suitable to effectively respond to the fire. The attempts by the salvors to request for XP to

[183] At this time the ship had five bottles of $CO_2$ remaining.

be brought into port were unsuccessful. The salvors' view that alternative ports of Hambantota and Trincomalee would have posed more challenges given the SW monsoon were noted by the investigation team.

2.7.1.8 The investigation team thus opined that there was a lack of coordination amongst the various stakeholders ashore to find a common solution in the handling of this emergency. While it is understandable that the Port of Colombo was protecting the facilities considering the risks to other ships at the time, the safety of the crew onboard should have also been taken into consideration when an emergency was being handled within the port limits.

2.7.1.9 While coordinating the firefighting efforts and positioning of the tugs was being done by the salvors, in the absence of a forthcoming response to move XP to sheltered waters, deployment of powerful tugs secured with tow-line connected to centre lead of XP's stern, could have aided in orientating the ship's bow downwind which would have minimised the fanning of the fire which rapidly spread towards the accommodation and the engine room.

2.7.2 Deployment of tugs for firefighting

2.7.2.1 When fire was reported on the top tier of the containers on deck on 20 May 2021 at about 2300H, tugs were deployed by the Colombo Port Control on 21 May 2021 around 0120H. Thereafter, the tugs, being a part of port services (to assist in berthing/ unberthing of other ships) were repeatedly called back to port for other port duties. There was thus a lack of continuity on firefighting support from the tugs until the XP was abandoned on 25 May 2021.

2.7.2.2 It was also evident that some of the tugs were not dedicated for firefighting and hence had their limitations to fight the fire effectively. The investigation team noted from several accounts that of all the tugs (eight) which rendered firefighting assistance, only "Hercules" was effective in firefighting efforts.

2.8 Development and spread of the fire.

2.8.1 Correlating the orange/ brown smoke that was being emitted in large volumes (see **para 1.2.21.4** and **figures 6 & 7**) after the release of $CO_2$, when the Sri Lankan Navy personnel were onboard, the investigation team considered the likelihood of leaked Nitric Acid's reaction with the metal construction of the

container, which probably became excessive causing an exothermic reaction, forming oxides of Nitrogen, and thus resulting in more orange fumes.

2.8.2 IMDG Class 5.1 substances which, in certain circumstances directly or indirectly evolve oxygen. As such, there is an increased risk and intensity of fire when Class 5.1 substance come into contact with combustible material. As evident from the increase in temperatures (especially on the starboard side), it was thus likely that at this stage multiple reactions were taking place in the vicinity of container *FSCU7712266* and within cargo hold #2.

2.8.3 The cause of “explosion” as reported by the crew from inside cargo hold #2 could not be determined with certainty. The investigation team noted from the stowage plan (see **figures 34** and **35**), that below the leaking container *FSCU7712264*, there were total of nine containers of Prilled Urea (see **para 1.9.10.6**).

2.8.4 As opined by the FFE, prior to the explosion, the salvors detected the presence of ammonia smell which could have been caused by the decomposition of one or more of these Urea containers, either by way of thermal decomposition and/ or reaction with moisture. It is possible that some of the containers of urea decomposed rapidly giving rise to the rapid generation of ammonia and hence, an exothermic reaction and the subsequent explosion.

2.8.5 The flame seen by the Master at the top tier in the region of 110582, which was consistent with the burn marks on the topmost container as seen in **figure 12**, was in all probability due to some contents of containers reacting with the heat in the area to catch fire, which subsequently resulted in an explosion about 24 hours later in the vicinity of bay 10.

2.8.6 Although the cargo onboard XP were stowed in accordance with the provisions of the IMDG Code, when the fire spread, the risk to other cargo stowed in the vicinity increased. Therefore, at the onset of a fire, it is vital to take steps to minimise its effect on other cargo in the vicinity.

2.9 Incidental findings

2.9.1 SMS

2.9.1.1 The Company's SMS for handling a leaking container was largely restricted to actions to be taken on discovery of the leak and notification to relevant parties. Despite there being no specific procedures for an emergency response plan to expeditiously offload the leaking container, the Company worked with various stakeholders to arrange for its discharge.

2.9.1.2 Although the SMS also expected the ship's crew to refer to the EmS of the IMDG Code, the ship's crew were not aware of the contents and nature of the leaking DG cargo. An improvement in the SMS for clarity was thus deemed desirable as opined by the investigation team.

2.9.2 Abandon ship

2.9.2.1 Despite XP being equipped with a freefall lifeboat which was designed and approved to aid in abandon ship, due to the thick smoke and ammonia fumes accumulation on deck, the crew were unable to board the lifeboat. Similarly, for the same reasons, the crew did not use the life rafts to abandon ship.

2.9.2.2 The crew were also unable to transfer to the assisting tug via the gangway due to rough seas and swell at the time.

2.9.2.3 XP was fortunate to have been assisted by tug "Hercules" which was able to evacuate all persons using the mooring ropes, although not a conventional method, secured to the stern bollard onboard XP with the free end leading down to the tug.

2.9.2.4 Although XP was provided with means of escape for the crew to abandon ship, this incident showed that access to such lifesaving equipment may be compromised by smoke reaching the accommodation. Such possibilities and limitations should be borne in mind when making the decision to abandon ship.

2.9.3 Declaration of Nitric Acid and its concentration

2.9.3.1 The actual cargo of container *FSCU7712264* was NITRIC ACID other than red fuming with at least 65% but with no more than 70%, the declaration of the

PSN was only NITRIC ACID without mentioning its concentration (see **para 1.9.4.2**). Although the IMDG Code does not mandate the text in lower case to be included in the PSN, such text which better describes the concentration of Nitric Acid may still be used.

2.9.3.2 The concentration of the Nitric Acid, in container *GESU2837027*, as tested by the independent laboratory at the request of the FFE was between 65 and 70%. There is a high probability that the cargo in container *FSCU7712264* was also of the same concentration.

2.9.3.3 The manifest further indicated an EmS schedule of S-B which is applicable to a concentration of less than 65% concentration (see **para 1.9.7.3**). The information captured in the Operator's software for DG stated the concentration to be more than 70% (see **para 1.9.7.5**). This seems to suggest that various stakeholders had different information about the declared concentration of this consignment.

2.9.3.4 Had the PSN for this container been declared according to **table 11**, all stakeholders including the Master and crew would have been aware of the actual concentration of the Nitric Acid being shipped in container *FSCU7712264*.

2.9.4 Communication barriers and maritime English

2.9.4.1 Although an announcement was made on the PA in English and Mandarin, the investigation team could not establish the reasons for the Master to sound the general emergency alarm, instead of the fire alarm, as per the Company's SMS.

2.9.4.2 XP's delivery crew were mostly from China. Although the Chinese crew were reportedly conversant with the ship and its operation, language barriers was evident between the Chinese and non-Chinese crew.

2.9.4.3 XP's official language was English. For operational efficacy, instructions or announcements were made in English and Mandarin. However, the possibility of the language barriers to have hampered the emergency response including allocation of roles to the off-signers exists.

2.9.4.4 There is no mandatory assessment of English proficiency for the purpose of training, manning and crew evaluation. Noting the challenges identified in **para 1.6.6**, i.e., the level of English proficiency varies and is a complex topic to manage by the industry the investigation team deemed that it is of utmost importance that the crew employed for any ship are able to converse effectively in the official language of the ship, for the safety of the crew onboard each ship.

2.9.4.5 Such effectiveness should be assessed by the Company at the time of recruitment and during their service onboard. If this is not done, there is a risk that language barriers could result in undesirable consequences.

## 3 CONCLUSIONS

3.1 As most of the evidence was destroyed by fire, the cause of the fire could not be conclusively established. However, from the events leading up to the fire, Nitric Acid from a container that had leaked, which in all probability contributed to the development of the fire onboard XP.

3.2 Based on the condition of the IBCs in container *GESU2837027* which had Nitric Acid leaking, the investigation team deduced that the IBCs inside container *FSCU7712264,* which were stacked and packed by the same Exporter, were in a similar poor condition that could have contributed to the leaking of Nitric Acid. The requirements of the CTU Code and the IMDG Code had not been complied with.

3.3 When the leak from container *FSCU7712264* was first discovered at the Port of Hamad, despite it having placards of IMDG Class 8 and 5.1, the crew did not check details of the cargo and proceeded to use sawdust to contain the leak. The use of inert absorbent pads should have been considered followed by the use of copious amounts of water to dilute the concentration of Nitric Acid after departing the Port of Hamad.

3.4 Bad weather conditions after XP's departure from the Port of Hazira did not allow for the leak from container *FSCU771226* to be actively monitored, which had likely increased after XP departed the Port of Hazira, due to the rolling and pitching. The leaked Nitric Acid had not been washed away and could have made its way down to cargo hold #2.

3.5 Nitric Acid being highly corrosive with oxidising properties, likely resulted in an exothermic reaction after coming into contact with the door rubber seals of the top tier containers at bay 10, which further compromised containers at the centre row containing Methanol. The exothermic reactions subsequently developed into large fires.

3.6 The B15 provisions in the IMDG Code require the IBCs used for the shipment of Nitric Acid to be not more than two years from the date of manufacture. The

date of manufacture of IBCs was not known to the Shipper and the Operator as there were no requirements for this to be indicated in the booking process.

3.7 When Nitric Acid from container *GESU2837027* was found to be leaking, a detailed inspection was not carried out early to determine the cause of the leak and an opportunity was missed, given that container *FSCU7712264* (with the same contents) was booked by the same Shipper.

3.8 The information of the leak in container *GESU2837027* was not made known to other parties (e.g. the Operator, the Company or the ship's crew). If the condition of the IBCs in container *GESU2837027* was assessed and made known earlier, container *FSCU7712264* could have been prevented from being loaded onboard XP or efforts to offload *FSCU7712264* could have been increased.

3.9 Although efforts were made to offload container *FSCU771226*, there seemed to be a lack of coordinated efforts to ensure this was done expeditiously for the safety of the crew and the ship. The Master's request to offload the container was not supported by the ports, citing insufficient information or insufficient capability to handle a leaking container of Nitric Acid. The coordination between the Company and the Ports in Hamad and Hazira could have been better.

3.10 Ships have limited resources to handle a leaking container, especially if it contains DG. The offloading of container *FSCU7712266* from XP may have prevented the subsequent risk of fire/ explosion as the Nitric Acid leakage could have been handled appropriately by relevant personnel.

3.11 The VDR data was not available to the investigation team which could have provided insights to the development of the emergency and the response by shoreside personnel.

3.12 When the Master gave orders to close all ventilation (mechanical fan and natural) flaps for cargo hold #2, some of the ventilation flaps on the starboard side could not be closed due to the presence of smoke and heat. The non-

closure of the starboard side natural ventilation flaps had resulted in the cargo hold #2 not being completely sealed prior to the discharge of $CO_2$.

3.13 When $CO_2$ was discharged, there was no verification on the actual quantity to be released given the loading condition of cargo hold #2. This resulted in XP's entire bank of $CO_2$ to be exhausted in one release.

3.14 The command and control onboard XP in handling the emergency lacked in coordination and resources were not used effectively. XP's muster list was not used to manage the resources effectively. The on-signers being new onboard were managing the emergency by randomly allocating crew to respond. Leading the various teams was also not coordinated. The off-signers were used for boundary cooling in the early stage, but they were not assigned to specific roles, taking their experience onboard into consideration which would have enabled a better response. As the emergency unfolded, the off-signers refused to participate in the emergency.

3.15 None of the crew (including the Emergency team) donned SCBA sets and fireman's outfits at the early stage of the emergency to gather more accurate information of the situation in cargo hold #2 and to fight fire in the presence of toxic smoke.

3.16 The ventilation flaps on XP were typical of container ships which require time and efforts to close. Closing the ventilation flaps while tackling heat and smoke is even more challenging. It is likely that these challenges had not been taken into consideration when assigning the task to the crew.

3.17 The response from Colombo Port Control to assist XP was deemed limited. There was no follow-up after a team of firemen had assessed the situation onboard XP. The tugs sent for firefighting had various limitations which did not offer continuous firefighting support. The Master did not receive answer from Colombo Port Control on the several requests made for urgent berthing before the fire went out of control.

3.18 The instruction for the ship to be towed away from the port, citing pollution risk, was contrary to the intention of the salvors to manage the incident closer into the port rather than to fight the fire at the anchorage where the weather conditions were not favourable. There was a lack of coordination amongst the

stakeholders ashore to find a common solution in the handling of this emergency to ensure the safety of the crew onboard and to prevent the vessel's condition from deteriorating.

3.19 When the salvors boarded the ship, they had limited time to assess the situation while coordinating the firefighting efforts with tugs which had limited ability. The salvors were unable to orientate XP's bow to a position that minimised the fanning of the fire by the prevailing winds, causing the fire to spread aft and towards the accommodation and engine room.

3.20 The smoke and fire engulfed the aft of the ship made it impossible for the crew to use the designated means of escape such as the freefall lifeboat to abandon ship. As a result, the crew had to use the mooring rope to descend onto a tugboat.

3.21 The concentration of Nitric Acid was not indicated under the PSN. As a result, various stakeholders had different information about the declared concentration of the Nitric Acid.

3.22 Although there is no mandatory assessment of English proficiency for the purpose of training, manning and crew evaluation, this occurrence depicted that language barriers amongst crew existed. It is vital to ensure that such barriers are minimised by ensuring all crew are able to converse and interact in the official language on board.

## 4 SAFETY ACTIONS

4.1 Arising from discussions with the investigation team, the stakeholders have taken the following safety actions.

4.2 On August 2021, a Central DG Desk department comprising a DG Specialist was formed to lead the DG Desk under the Head Global Operations in the Operator's organisation. The task of this department, in addition, to receiving all DG applications, also includes:

- The DG approval for carriage & stowage onboard prior loading;
- Ensuring all NVOCC provides their Company's DG policy and insurance coverage for acceptance;
- Ensuring that all pre-vetted NVOCC allowed to load DG meet the requirements of the IMDG Code; and
- Ensuring no DG will be accepted from small Ship Operators.

4.3 The Company amended their onboard training schedule to further enhance the training on emergency response and increase the frequency of training on the operation of fixed $CO_2$ firefighting system to monthly.

4.4 The Company's IMDG Cargo instructions – Procedure for the carriage of IMDG cargo, were reviewed and amended to include "General Guidelines for Spillage", which among others, includes,

- Avoid any contact with dangerous substance and keep away from vapours;
- Identify cargo, obtain UN Numbers and the EmS Spillage Schedule of dangerous goods involved; and
- Wear full protective clothing resistance to chemical and SCBA sets.

4.5 The Company also included an orientation training checklist to conduct familiarisation onboard for all personnel joining the ship. Multiple procedures and operation of equipment & systems were added to the list of training to be completed within a stipulated time, including activation of fixed $CO_2$ firefighting system. For example, Master, CO, CE and 2E are required to know the location

and activation of the fixed $CO_2$ firefighting system within one week of joining or before taking over duty.

4.6 The Company reviewed the Master's Authority by including the following -

- Master must take effective action to resolve all issues and ensure safe carriage of cargo throughout the voyage;
- Issues that are related to DG leaking & malfunction of reefer unit must be dealt with utmost attention; and
- Master shall exercise overriding authority to reject/discharge the unit or even delay the vessel departure if deemed necessary, until the discrepancy is resolved to Master's satisfaction.

## 5 SAFETY RECOMMENDATIONS

*A safety recommendation is for the purpose of preventive action and shall in no case create a presumption of blame or liability.*

5.1 For the Company (Eastaway Ship Management)

5.1.1 To ensure its crew respond to shipboard fire emergency in accordance with the muster list stipulated in the ship's SMS. **[TSIB Recommendation RM-2023-12]**

5.1.2 To ensure its crew are familiar with the use of emergency equipment onboard, such SCBA set, in the event of shipboard fire. **[TSIB Recommendation RM-2023-13]**

5.1.3 To review its SMS in ensuring all resources onboard are utilised effectively and the handing and taking over of duties and responsibilities is deferred, in the event of an emergency.**[TSIB Recommendation RM-2023-14]**

5.1.4 To ensure crew onboard its ships are able to communicate in the official language. **[TSIB Recommendation RM-2023-15]**

5.2 For the Operator (X-Press Feeders)

5.2.1 To review its booking process to ensure it takes into consideration the special provisions such as B15, of the IMDG Code. **[TSIB Recommendation RM-2023-16]**

5.3 For the Shipper (Transvision)

5.3.1 To review its procedures to ensure containers are packed and shipped in accordance with the requirements of the CTU Code. **[TSIB Recommendation RM-2023-17]**

5.3.2 To review its procedures to ensure the training of its personnel involved in cargo booking process takes into consideration the special provisions such as B15, of the IMDG Code. **[TSIB Recommendation RM-2023-18]**

5.4 For the Authority for the Port of Colombo

5.4.1 To review its plans for supporting a response to a shipboard fire by ensuring that tugs assigned for firefighting are fit for purpose and dedicated in performing firefighting. **[TSIB Recommendation RM-2023-19]**

5.4.2 To take appropriate steps for ensuring the voyage data recorder (VDR), when recovered, is made available to the flag State for the conduct of safety investigation as required by the IMO Guidelines on VDR ownership and recovery (MSC/Circ.1024). **[TSIB Recommendation RM-2023-20]**

# 6 APPENDICES

## 6.1 Appendix 1 - Properties of Nitric Acid per DG List (IMDG Code)

| Column | Category | Description | | |
|---|---|---|---|---|
| 1 | UN no. | 2031 | | |
| 2 | Proper shipping name | NITRIC ACID other than red fuming, with more than 70% Nitric Acid | NITRIC ACID other than red fuming, with at least 65% but with not more than 70% Nitric Acid. | NITRIC ACID other than red fuming, with less than 65% Nitric Acid |
| 3 | Class or division | 8 | | |
| 4 | Subsidiary risk(s) | 5.1[184] | 5.1[185] | - |
| 5 | Packing group[186] | I | II | II |
| 6 | Special provisions | - | | |
| 7a | Limited quantities | | | |
| 7b | Exceptional quantities | | | |
| 8 | Packaging – Instructions | P001[187] | | |
| 9 | Packaging – Provisions | PP81[188] | | |
| 10 | IBC – Instructions | - | IBC02[189] | IBC02 |

[184] Powerful oxidant.
[185] Oxidant.
[186] (From IMDG Code) *Packing groups are assigned to three packing groups in accordance with the degree of danger they present:*
- *a. Packing group I: substances presenting high danger;*
- *b. Packing group II: substances presenting medium danger; and*
- *c. Packing group III: substances presenting low danger.*

[187] Packing instructions concerning the use of packaging (except IBCs and large packaging) for liquids
[188] For UN 2031 with more than 55% Nitric Acid, the permitted use of plastics drums and jerricans as single packaging shall be two years from their date of manufacture.
[189] Packing of liquid Nitric Acid is authorised using metal, rigid plastics, and composite.

| | | | | |
|---|---|---|---|---|
| 11 | IBC – Provisions | - | B20[191] | B15<br>B20 |
| 12 | Portable tank and bulk containers | [Reserved] | | |
| 13 | Portable tank and bulk containers – Tank instructions | T10[192] | T8[193] | T8 |
| 14 | Portable tank and bulk containers – Provisions | TP13[195] | TP2 | TP2 |
| 15 | EmS | F-A[196], S-Q[197] | F-A, S-Q | F-A, S-B[198] |
| 16a | Stowage and handling | Category D[199] | | |
| 16b | Segregation[200] | SG6[201]<br>SG16[202]<br>SG17[203]<br>SG19[204] | SG16<br>SG17<br>SG19 | - |

[190] For UN 2031 with more than 55% Nitric Acid, the permitted use of rigid plastics IBCs and of composite IBCs with a rigid plastics inner receptacle shall be two years from their date of manufacture.
[191] IBCs shall be fitted with two shut-off valves.
[192] IMDG Code 4.2.5.2.6 (Portable tank instructions) and 6.7.2.4.2 (Minimum shell thickness).
[193] See footnote 89.
[194] IMDG Code 4.2.5.3 (Portable tank special provisions) and 4.2.1.9 (Degree of filling).
[195] SCBA sets shall be provided when this substance is transported.
[196] FIRE SCHEDULE Alfa.
[197] SPILLAGE SCHEDULE Quebec.
[198] SPILLAGE SCHEDULE Bravo.
[199] ON DECK ONLY – Cargo ships or passenger ships carrying a number of passengers limited to not more than 25 or to 1 passenger per 3m of overall length, whichever is the greater number.
[200] The process of separating two or more substances or articles which are considered mutually incompatible when their packing or stowage together may result in undue hazards in case of leakage or spillage, or any other accident.
[201] Segregation as for class 5.1.
[202] Stow “separated from” class 4.1.
[203] Stow “separated from” class 5.1.
[204] Stow “separated from” class 7.

| | | | | |
|---|---|---|---|---|
| 16b | Segregation[205] | SG6[206]<br>SG16[207]<br>SG17[208]<br>SG19[209] | SG17 | - |
| 17 | Properties and observations | Colourless liquid. may cause fire in contact with organic materials such as wood, cotton or straw, evolving highly toxic gases (brown fumes). Highly corrosive to most metals. Causes severe burns to skin, eyes and mucous membranes. | | |

[205] The process of separating two or more substances or articles which are considered mutually incompatible when their packing or stowage together may result in undue hazards in case of leakage or spillage, or any other accident.
[206] Segregation as for class 5.1.
[207] Stow “separated from” class 4.1.
[208] Stow “separated from” class 5.1.
[209] Stow “separated from” class 7.

## 6.2 Appendix 2a – Properties of other DGs (IMDG Code)

| Column | Category | Description | |
|---|---|---|---|
| 1 | UN no. | 1230 | 1823 |
| 2 | Proper shipping name | METHANOL | SODIUM HYDROXIDE, SOLID |
| 3 | Class or division | 3[210] | 8 |
| 4 | Subsidiary risk(s) | 6.1[211] | - |
| 5 | Packing group[212] | II | II |
| 6 | Special provisions | 279[213] | - |
| 7a | Limited quantities | 1 L | 1 kg |
| 7b | Exceptional quantities | E2 | E2 |
| 8 | Packaging – Instructions | P001 | P002 |
| 9 | Packaging – Provisions | - | - |
| 10 | IBC – Instructions | IBC02 | IBC08[214] |
| 11 | IBC – Provisions | - | B4[215]<br>B21[216] |
| 12 | Portable tank and bulk containers | [Reserved] | |

[210] Flammable liquids.
[211] Toxic substances.
[212] (From IMDG Code) *Packing groups are assigned to three packing groups in accordance with the degree of danger they present:*
- *a. Packing group I: substances presenting high danger;*
- *b. Packing group II: substances presenting medium danger; and*
- *c. Packing group III: substances presenting low danger.*

[213] The substance is assigned to this classification or packing group based on human experience rather than the strict application of classification criteria set out in this Code.
[214] Packing of Sodium Hydroxide is authorised using metal, rigid plastics, composite, fibreboard, wooden and flexible.
[215] For UN 2031 with more than 55% Nitric Acid, the permitted use of rigid plastics IBCs and of composite IBCs with a rigid plastics inner receptacle shall be two years from their date of manufacture.
[216] IBCs shall be fitted with two shut-off valves.

| | | | |
|---|---|---|---|
| 13 | Portable tank and bulk containers – Tank instructions | T7[217] | T3[218] |
| 14 | Portable tank and bulk containers – Provisions | TP1[219] | TP33[220] |
| 15 | EmS | F-E[221], S-D | F-A, S-Q |
| 16a | Stowage and handling | Category B[222]<br>SW2[223] | Category A[224] |
| 16b | Segregation[225] | - | SG35[226] |
| 17 | Properties and observations | Colourless, volatile liquid. Flashpoint: 12˚c.c. Explosive limits: 6% to 36.5%. Miscible with water. Toxic if swallowed; may cause blindness. Avoid skin contact. | White pellets, flakes, lumps or solid blocks, deliquescent. Reacts with ammonium salts, evolving ammonia gas. In the presence of moisture, corrosive to aluminium, zinc and tin. Causes burns to skin, eyes and mucous membranes. Reacts violently with acids. |

[217] IMDG Code 4.2.5.2.6 (Portable tank instructions).
[218] IMDG Code 4.2.5.2.6 (Portable tank instructions).
[219] IMDG Code 4.2.5.3 (Portable tank special provisions) and 4.2.1.9 (Degree of filling).
[220] The portable tank instruction assigned for this substance applies for granular and powdered solids and for solids which are filled and discharged at temperatures above their melting point, and which are cooled and transported as a solid mass.
[221] FIRE SCHEDULE Echo.
[222] ON DECK OR UNDER DECK – Cargo ships or passenger ships carrying a number of passengers limited to not more than 25 or to 1 passenger per 3 m of overall length, whichever is the greater number.
[223] Clear of living quarters.
[224] ON DECK OR UNDER DECK – Cargo ships or passenger ships carrying a number of passengers limited to not more than 25 or to 1 passenger per 3 m of overall length, whichever is the greater number.
[225] The process of separating two or more substances or articles which are considered mutually incompatible when their packing or stowage together may result in undue hazards in case of leakage or spillage, or any other accident.
[226] Stow “separated from” acids.

## 6.3 Appendix 2b – Properties of other DGs (IMDG Code)

| Column | Category | Description | |
|---|---|---|---|
| 1 | UN no. | 1301 | 1266 |
| 2 | Proper shipping name | Vinyl Acetate, Stabilised | Perfumery products |
| 3 | Class or division | 3 | 3 |
| 4 | Subsidiary risk(s) | - | - |
| 5 | Packing group[227] | II | II |
| 6 | Special provisions | 386[228] | 163 |
| 7a | Limited quantities | 1 L | 5 L |
| 7b | Exceptional quantities | E2 | E2 |
| 8 | Packaging – Instructions | P001 | P001 |
| 9 | Packaging – Provisions | - | - |
| 10 | IBC – Instructions | IBC02 | IBC02 |
| 11 | IBC – Provisions | - | - |
| 12 | Portable tank and bulk containers | - | |
| 13 | Portable tank and bulk containers – Tank instructions | T4[229] | T4 |
| 14 | Portable tank and bulk containers – Provisions | TP1[230] | TP1<br>TP8 |
| 15 | EmS | F-E, S-D | F-E, S-D |

[227] (From IMDG Code) *Packing groups are assigned to three packing groups in accordance with the degree of danger they present:*

*a. Packing group I: substances presenting high danger;*
*b. Packing group II: substances presenting medium danger; and*
*c. Packing group III: substances presenting low danger.*

[228] The substance is assigned to this classification or packing group based on human experience rather than the strict application of classification criteria set out in this Code.

[229] IMDG Code 4.2.5.2.6 (Portable tank instructions).

[230] IMDG Code 4.2.5.3 (Portable tank special provisions) and 4.2.1.9 (Degree of filling).

| | | | |
|---|---|---|---|
| 16a | Stowage and handling | Category C[231]<br>SW1[232] | Category B |
| 16b | Segregation[233] | - | - |
| 17 | Properties and observations | Colourless, to light yellow liquid, Flashpoint: -8° C c.c. Explosive limits: 2.6% to 14%. Immiscible with water. | Miscibility with water depends upon the composition. |

[231] ON DECK OR UNDER DECK – Cargo ships or passenger ships carrying a number of passengers limited to not more than 25 or to 1 passenger per 3 m of overall length, whichever is the greater number.
[232] Clear of living quarters.
[233] The process of separating two or more substances or articles which are considered mutually incompatible when their packing or stowage together may result in undue hazards in case of leakage or spillage, or any other accident.

## 6.4 Appendix 3 – Carriage of DG onboard XP

| **Breakdown of DG cargo on deck from bays 09 to 15** | | | | | | |
|---|---|---|---|---|---|---|
| Item description (in manifest) | Container Length | No. of containers | DG Class no. | UN no. | EmS | Proper Shipping Name |
| Methanol | 20-foot | 2 | 3 | 1230 | F-E / S-D | Methanol |
| Vinyl acetate, stabilised | 20-foot | 2 | 3 | 1301 | F-E / S-D | Vinyl acetate, stabilised |
| Nitric Acid | 20-foot | 1 (110582) | 8 | 2031 | F-A / S-Q | Nitric Acid other than red fuming, with at least 65% but with not more than 70% Nitric Acid |
| Polymeric beads, expandable | 20-foot | 1 | 9 | 2211 | F-A / S-I | Polymeric beads, expandable evolving flammable vapour |
| Environmentally hazardous substance liquid N.O.S. | 20-foot | 1 | 9 | 3480 | F-A / S-I | Lithium-ion batteries (including lithium-ion polymer batteries) |
| **Breakdown of DG cargo below deck in cargo hold #2** | | | | | | |
| Caustic Soda | 20-foot | 26 | 8 | 1823 | F-A / S-B | Sodium hydroxide, solid |
| Extinguisher | 45-foot | 4 | 2.2[234] | 1044 | F-C / S-V | Fire extinguishers with compressed or liquefied gas |
| | | 2 | | 1013 | F-C / S-V | Carbon dioxide |
| Assorted perfumes | 20-foot | 2 | 3 | 1266 | F-E / S-D | Perfumery products with flammable solvents |
| Methanol | 45-foot | 2 | 3 | 1230 | F-E / S-D | Methanol |
| Sodium methylate solution | 20-foot | 2 | 3 | 1289 | F-E / S-C | Sodium methylate solution in alcohol |
| Sodium methoxide | 20-foot | 1 | 4.2[235] | 1431 | F-A / S-L | Sodium methylate |

[234] Division 2.2: Non-flammable, non-toxic gases.
[235] Division 4.2: Substances liable to spontaneous combustion.

6.5 Appendix 4 – Details of Tugs which rendered firefighting assistance.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
|  | |  | |  | |  | |
| **Name:** | Megha | **Name:** | Hercules | **Name:** | Maha Wewa | **Name:** | Posh Hardy |
| **Type:** | Firefighting vessel | **Type:** | Tug | **Type:** | Tug | **Type:** | Tug |
| **Flag:** | Sri Lanka | **Flag:** | Sri Lanka | **Flag:** | Sri Lanka | **Flag:** | Sri Lanka |
|  | |  | |  | |  | |
| **Name:** | Posh Teal | **Name:** | Prantik Sarwar (ex. Pacific Parakeet) | **Name:** | Aries | **Name:** | Astro Capella |
| **Type:** | Multi-purpose offshore vessel | **Type:** | Firefighting vessel | **Type:** | Anchor handling vessel | **Type:** | Firefighting vessel |
| **Flag:** | Singapore | **Flag:** | Singapore | **Flag:** | Sri Lanka | **Flag:** | Panama |