Panama Maritime Authority
General Directorate of Merchant Marine
Maritime Affairs Investigation Department

MV "FREMANTLE HIGHWAY"
IMO 9667344
FIRE ON BOARD
Casualty Date: July 25th 2023
Casualty Place: Northsea – The Netherlands EEZ
VERY SERIOUS MARINE CASUALTY
REPORT NUMBER: R-016-2024-DIAM

SAFETY INVESTIGATION REPORT

FIRE ON BOARD M/V FREMANTLE HIGHWAY

At Northsea – The Netherlands EEZ

On July 25th, 2023

DISCLAIMER

This safety investigation report will be subject only to the purposes stated in the ***Code of the International Standards and Recommended Practices for a Safety Investigation into a Marine Casualty or Marine Incident (hereinafter the "Casualty Investigation Code"),*** adopted by the IMO Maritime Safety Committee, at its eighty-fourth session by resolution MSC.255(84).

National Legal Framework:

1. General Law No.57 of Merchant Marine
2. Resolution No.106-033-DGMM of May 23th, 2022, General Directorate of Merchant Marine, Panama Maritime Authority.

Note: This investigation report should not serve as evidence to determine liability, or apportion blame.

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OBJECTIVES OF THE MARINE SAFETY INVESTIGATIONS & MARINE SAFETY INVESTIGATION REPORTS

Marine Safety Investigations do not seek to apportion blame or determine liability. Instead a marine safety investigation, as defined in the Casualty Investigation Code, is an investigation conducted with the objective of preventing marine casualties and marine incidents in the future.

The main objectives of the present report can be defined as follows:

1. To enable a wide dissemination of information to assist the international marine industry to address safety issues.
2. Identifying and reporting the causal factors that led to the incident.
3. To propose the best safety recommendations to avoid similar events in the future.

***Important Notice*: during this Safety Investigation, the Panama Maritime Authority acted as the Lead Investigating State with the collaboration of The Netherlands and The United Kingdom, both acting as Substantially Interested States.**

USED ABBREVIATIONS

AIS	Automatic Identification System	KW	Kilowatts
AMSA	Australian Maritime Safety Authority	LB	Life Boat
BA	Breathing Apparatus	LBP	Length between Perpendiculars
BEV	Battery Electric Vehicle	LOA	Length Overall
BF	Beaufort Wind Force Scale	LR	Life Rafts
BHP	Brake Horse Power	LSA	Life-Saving Appliances
COC	Certificate of Competency	LT	Local Time
COE	Certificate of Endorsement	M/E	Main Engine
C/O	Chief Officer	MSC	Maritime Safety Committee
DGMM	General Directorate of Merchant Marine (Panama)	MSM	Minimum Safe Manning
DSB	Dutch Safety Board	MT	Metric Tons
ECR	Engine Control Room	Mts	Meters
E.G.	Exempli Gratia, For Example	M/V	Motor Vessel
ETA	Estimated Time of Arrival	NKK	Nippon Kaiji Kyokai
ETD	Estimated Time of Departure	NLCG	Netherland Coast Guard
EV	Electrical Vehicle	NM	Nautical Miles
E/R	Engine Room	NT	Net Registered Tonnage
FFE	Fire Fighting Equipment	NUC	Not Under Command
GPS	Global Positioning System	O/B	On Board
GRT	Gross Registered Tonnage	PHEV	Plug-in hybrid electric vehicles
HRS	Hours	PMA	Panamanian Maritime Authority
ICE	Internal Combustion Engine	PSC	Port State Control
IMO	International Maritime Organization	P&I	Protection and Indemnity Club
ISM	International Safety Management	RCA	Root Cause Analysis
KNRM	The Royal Dutch Rescue Organisation	RCC	Rescue Coordination Center

R.O.	Recognized Organization		
RPM	Revolutions per Minute		
SECA	Sulphur Emission Control Areas		
SOLAS	Safety of Live at Sea		
SMS	Safety Management System		
STCW	Standards of Training Certification and Watch keeping		
TSS	Traffic Separation Scheme		
UMS	Unattended Machinery Space		

SOURCES OF INFORMATION & EVIDENCE

The present report has considered the below-listed parameters and any findings included in the present casualty investigation report are based on the following:

- O/B physical inspection and verification from appointed fire expert for the nature/origin/ignition cause and extent of damages.
- VDR Data.
- Documentary evidence and training records.
- Interviews with the Master, C/O, C/E, Bosun, Electrical Engineer, AB, Deep Sea Pilot, Superintendent Captain, as well as company representatives.
- Information collected by DSB in their role as Substantially Interested State, or on request of PMA as Lead Investigating State.
- The Netherlands Coastguard rescue operation radar/voice recording data.

The investigation entailed interviews after the casualty but also included the following:

1. Inspection of various data/documentation provided by operators and charterers in order to obtain and verify data including:
    a. Ships Particulars.
    b. Statement of facts by the involved crew members.
    c. Identify the sequence of events surrounding the casualty.
    d. Cargo/Vehicles (load/stowage) records.
    e. Crew list.
2. Verification of:
    a. Crewmembers qualifications (STCW, COC's, COE & Medical reports).
    b. Compliance with the MSM certificate.
    c. Company crew training procedures
    d. Charts and correspondences.
3. Review and evaluation of vessel class and statutory certificates issued by the R.O. /

Classification society, and Flag Administration of vessel.

4. Documentation related to Ship's Equipment (LSA/FFE)

    a. Technical data of:
        i. AIS
        ii. VDR
        iii. GPS
    b. Engine alarms print-out.

5. Documentary review of Safety Management System (SMS) and implementation onboard, with particular attention to:

    a. Details of Voyage plan.
    b. Crew familiarization records.
    c. Procedures of contingency plan.
    d. Procedure for Pilot o/b.
    e. Procedures for EV transportation.
    f. Implementation of contingency plan.
    g. Working/resting hours.
    h. Planned Maintenance Procedures & Records.
    i. Bridge manning at the time of the accident.
    j. Incident report, as per SMS Manual.
    k. Managers' standing instructions.
    l. Individual training records file.
    m. Non-conformities and/or accidents and/or near misses reports for the last year.
    n. Last internal Audit report.
    o. Last external Audit report.

6. Review and evaluation of the last PSC report.

7. Review and evaluation of charts, sailing directions and relevant reports provided by

vessel operators.

8. Analysis and examination of the layout of the location where the incident occurred.

It should be indicated that the hard copies and electronic records available on board were destroyed since the bridge and crew accommodation areas were totally burned. Various records and data were provided by operators and charterers.

SUMMARY

In the late hours (**23:00 hrs LT**) of **July 25th 2023**, the car carrier **M/V FREMANTLE HIGHWAY** was on its way from Germany (departed port Bremerhaven) to Singapore via Suez Canal/Egypt when a fire broke out (approximately at **23:11 hrs LT**). The exact location of the vessel at that time was ***(*53°46'N 006°41'E)**, approximately 27 kilometres north of the island of Ameland in the North Sea.

The vessel was reported to be loaded with **3,784 new vehicles** on board (including **498 electric vehicles "EV"**) and special construction machinery. The fire alarm was raised at about **23:10 hrs LT**; at that time, the 3rd Deck Officer was on bridge duty together with the watchkeeper AB. As a normal practice, the 3rd Deck Officer acknowledged the alarm on the indicator panel; the indication was a fire in **deck 8/hold 4**, and he was in the process of instructing the watchkeeper AB to go and check the subject deck/hold. At the same time, the Master was called on the Bridge (as per the Master's statement, he heard the alarm and went to the bridge to check), and he instructed the 3rd Deck Officer to join the AB in the inspection of **deck 8/hold 4.**

The AB arrived at the fire location, and a short while later, the 3rd Deck Officer joined him. They quickly located the fire by observing the resulting smoke and flames indicating the source/origin of the fire. The bridge/Master was advised accordingly (at about 23:14 hrs LT), and the General Alarm for fire was raised.

The crew were mustered at their muster station (12DK), and the fire emergency team (C/O in charge) prepared to investigate the suspected area further and attack/extinguish the fire. For the next approximately 40 min, regardless of the efforts of the fire teams as well as the deployment of the fixed fire extinguishing system (foam), the fire could not be controlled; instead, the fire spread furiously through the vessel, producing large amounts of smoke, heat and flames.

Master assessing the overall condition o/b, and taking into consideration that the fire could not be controlled, he ordered "abandon vessel", on about **01:37 hrs LT**; however, due to heat and heavy smoke, vessel LB/LR could not be used, and shore assistance (from NLCG) for vessel evacuation was requested, on about **02:03 hrs LT**. At the time of the fire, were 23 persons on board, including 21 Indian crew members, a Deepsea pilot (British Nationality) and a superintendent (Indian Nationality).

The crew rescue/evacuation operation was organised/handled by NLCG. A Dash 8 patrol aircraft, followed by two rescue boats and one support vessel, approached the vessel; several crewmembers (seven in totals) jumped (02:30 hrs LT 3rd Engineer officer, 02:55 hrs LT 6 crewmembers) into the sea/water and recovered from the water by the rescue boats.

However, taking into consideration the height from where the crewmembers were jumping into the sea/water and that they were picked up without their conscious, it was decided by the NLCG officer in charge of the rescue boats that this was not a safe manner for evacuation. Therefore, the crew o/b were instructed to stop jumping **(on about 03:16 hrs LT)** into the sea and waiting to be rescued from helicopters. Unfortunately, one of the jumped crewmembers (a 59-year-old A/B engine) died. The remaining 16 persons were gathered in the bridge area and rescued/winched by two helicopters; all of them were hospitalized in the Netherlands hospitals.

Although the towing connection was in place early on the morning of July 26, 2023, it was not until July 30, 2023, that the fire onboard the vessel produced significantly less smoke, making it possible to tow the ship to a port of refuge. On August 3, 2023, the vessel was secured against the quay at the port of Eemshaven, The Netherlands.

Chapter 1. GENERAL DETAILS OF THE VESSEL

1.1 The Ship – M/V FREMANTLE HIGHWAY

M/V FREMANTLE HIGHWAY is a Panama-registered car carrier vessel. The vessel is owned by "HIGAKI SANGYO KAISHA LTD - JAPAN (90% owned)" and "LUSTER MARITIME S.A. – PANAMA (10% owned)" and managed by "WALLEM SHIPMANAGEMENT LIMITED / HONK KONG." She was delivered in 2013 by IMABARI SHIPBUILDING CO., LTD, JAPAN, and classified by NKK. Statutory certificates, including SMC/ISSC/MLC, have been issued from "R.O." NKK.

The vessel charterer was KLINE/Japan.

M/V FREMANTLE HIGHWAY had an overall length of 197, 97.00m and a breadth (moulded) of 32.26m. She was designed with 12 cargo/cars decks and had a stowage capacity of 6,620 cars **(standard car l=4.50 b=1.70 h=1.42)**

Propulsive power is provided by one main engine, **"KOBE DIESEL CO. LTD**, **Type 8UEC60LS II ECO," which develops a total output of MCO 12,240KW at 94 RPM and drives one x 5-blade solid-type** propeller, Diam **6600**. Navigational (consistent with SOLAS requirements) and GMDSS communication equipment are located on the Ship's Bridge.

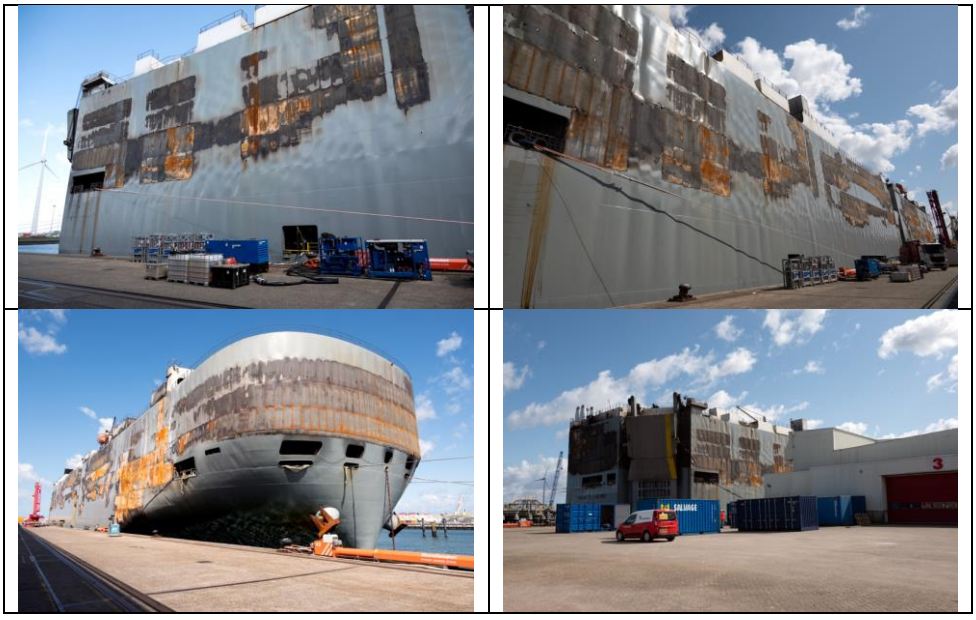


FIGURE 1: FREMANTLE HIGHWAY VIEW HULL
(Source: Photos taken during physical attendance o/b)

1.2 Ship's Particulars – M/V FREMANTLE HIGHWAY

OWNERSHIP/OPERATORS/CLASS	
Ship's Name	**FREMANTLE HIGHWAY**
IMO No	**9667344**
Call Sign	**3EYO5**
Flag	**Panama**
Port of Registry	**Panama**
Class	**NKK**
Type of Ship	**VEHICLES CARRIER**
Date of Build	**2013**
Shipyard	**IMABARI SHIPBUILDING Co. Ltd. / JAPAN**
Owners	**HIGAKI SANGYO KAISHA LTD – JAPAN (90% owned)" & "LUSTER MARITIME S.A. – PANAMA (10% owned)**
Operators	**WALLEM SHIPMANAGEMENT LIMITED**
Charterers	**KLINE/JAPAN**
DIMENSIONS	
Gross Tonnage	**59525 Tons**
Net Tonnage	**19152 Tons**
Deadweight (summer)	**18543 Tons**
Length O.A. / B.P.	**199.97 / 192.00 Meters**
Breadth (MLD)	**32.26 Meters**
Depth (MLD)	**14.70 Meters**

Freeboard (Summer)	**10.226 Meters**
Draft (Summer)	**10.017 Meters**
MACHINERY	
M/E Type	**8UEC60LS II ECO**
Manufacture	**KOBE DIESEL CO. LTD**
Power	**MCO 12,240KW@94 RPM**
Bow / Stern Thruster	**Kawasaki KT-157B5 Controllable pitch type**
Propeller	**Keyless Screw Propeller, Mitsubishi 6600 Dia-Blade Nos. 5**
Service Speed	**19,6 knots (service speed)**
CAPACITIES	
Cargo Holds	**12 Cargo car decks**
Total Capacity	**6220 cars (standard car l=4.50 b=1.70 h=1.42)**
FO (heavy) Capacity	**2679,87 m^3**
DO Capacity	**125,56 m^3**
FW Capacity	**659,25 m^3**
BW Capacity	**9267,82 m^3**

TABLE 1: VESSEL MAIN PARTICULARS
(Source: Vessel Certificates/Class records)

1.3 Ship's Certificates – M/V FREMANTLE HIGHWAY

The vessel was reported to have valid trading certificates during the fire/abandon incident on **25th July 2023**. Additionally, during the casualty investigation inspection, all vessel registry, statutory, and class certificates were examined/reviewed and found valid, as per the table below.

Class & Statutory Certificates (issued on behalf of Flag Administration)			
TYPE	ISSUED BY	EXPIRY	LAST SURVEY
CLASS	NKK	16/12/2023	11/10/2022
IAPP	NKK	16/12/2023	11/10/2022
IOPP	NKK	16/12/2023	11/10/2022
ISPP	NKK	16/12/2023	17/01/2019
CSSE	NKK	16/12/2023	11/10/2022
CSSR	NKK	16/12/2023	11/10/2022
CSSC	NKK	16/12/2023	11/10/2022
ILL	NKK	16/12/2023	11/10/2022
ITC-69	NKK	-	17/12/2013 (*issued date*)
ISSC	NKK	24/03/2024	16/02/2022
SMC	NKK	24/03/2024	16/02/2022
MLC	NKK	14/05/2024	16/02/2022
DOC	NKK	19/05/2025	23/05/2023

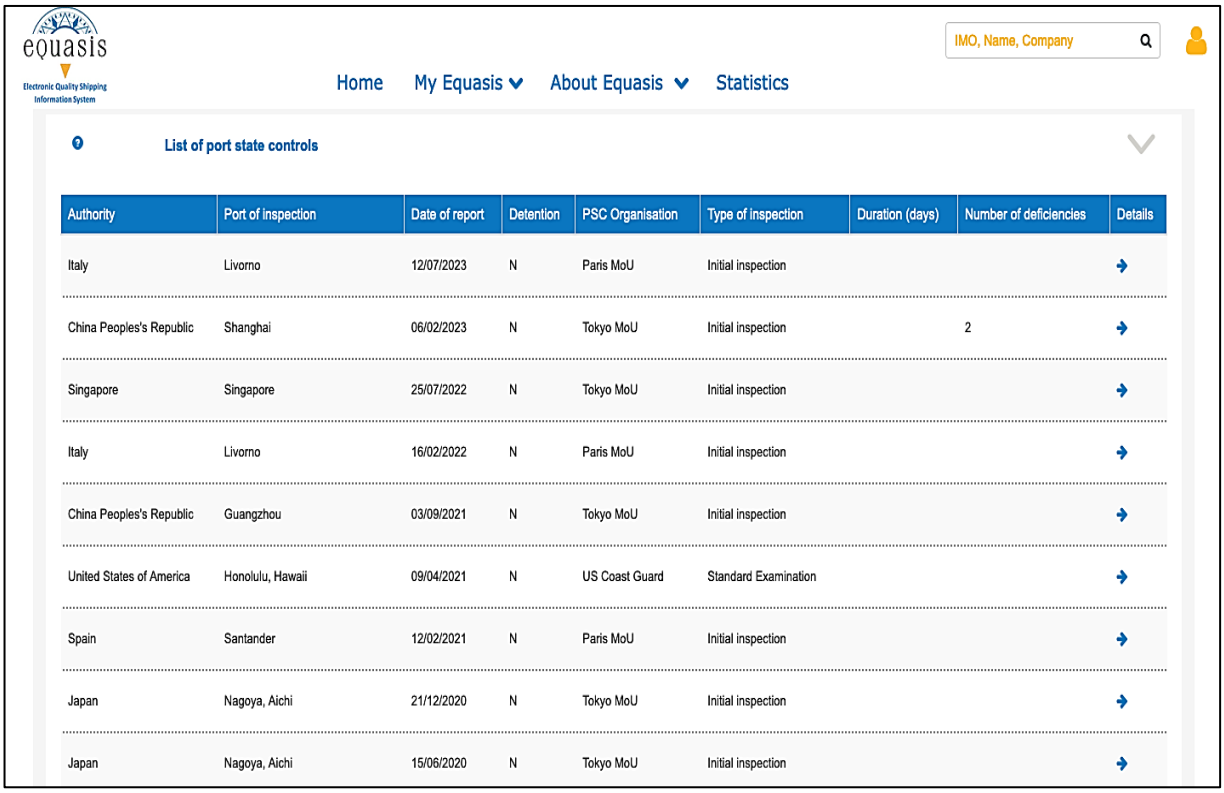
Certificates issued from Flag Administration			
TYPE	ISSUED BY	EXPIRY	LAST SURVEY
Navigation Registry	PMA	01/01/2024	-
MSM	PMA No M39320	-	12/01/2017 (*issued date*)
Radio Station License	PMA	28/03/2024	-
WRC	PMA	20/02/2024	-
CLC	PMA	20/01/2024	
CICA	PMA	27/02/2026	17/03/2022
IHMC	PMA	06/12/2023	10/10/2020
CSR	PMA No 4	-	15/11/2016 (*issued date*)

TABLE 2: VESSEL FLAG / CLASS / STATUTORY CERTIFICATES
(Source: Vessel Certificates/Class Status)

As per the above table, the vessel class status report was also examined in addition to reviewing and evaluating vessel certificates, and the vessel was found free of any defects or class conditions affecting its seaworthiness.

1.4 Inspections (Last PSC)

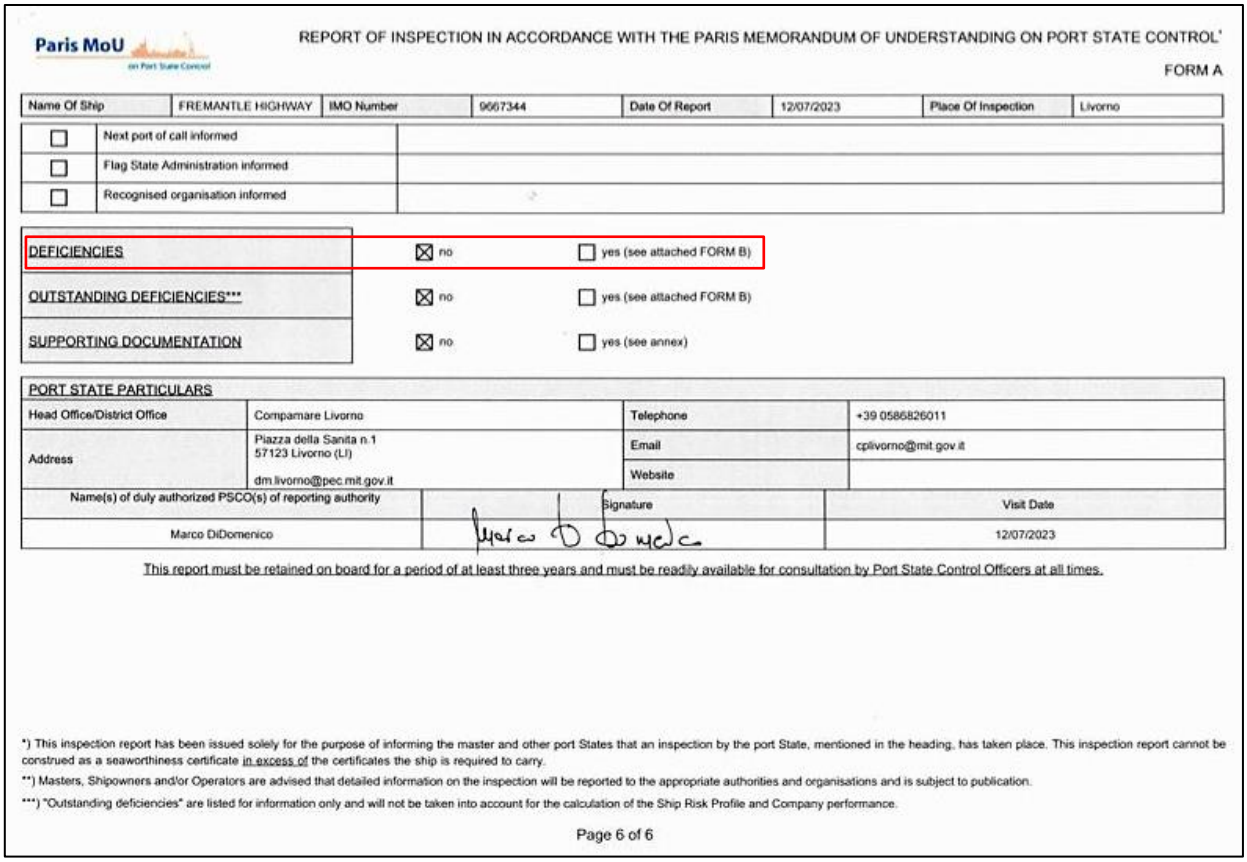
A review and examination of PSC inspection data for the previous three years before the fire incident was done to assess the general state of the vessel, the condition of LSA/FFE equipment, the crew members' performances, and the working circumstances.



Authority	Port of inspection	Date of report	Detention	PSC Organisation	Type of inspection	Duration (days)	Number of deficiencies	Details
Italy	Livorno	12/07/2023	N	Paris MoU	Initial inspection			
China Peoples's Republic	Shanghai	06/02/2023	N	Tokyo MoU	Initial inspection		2	
Singapore	Singapore	25/07/2022	N	Tokyo MoU	Initial inspection			
Italy	Livorno	16/02/2022	N	Paris MoU	Initial inspection			
China Peoples's Republic	Guangzhou	03/09/2021	N	Tokyo MoU	Initial inspection			
United States of America	Honolulu, Hawaii	09/04/2021	N	US Coast Guard	Standard Examination			
Spain	Santander	12/02/2021	N	Paris MoU	Initial inspection			
Japan	Nagoya, Aichi	21/12/2020	N	Tokyo MoU	Initial inspection			
Japan	Nagoya, Aichi	15/06/2020	N	Tokyo MoU	Initial inspection			

FIGURE 2-A: PORT STATE CONTROL INSPECTIONS RECORDS (2020-2023) (Source: Equasis)

Having reviewed PSC inspection records dated prior to the fire incident, it was noted that vessel records for years 2020-2023 (up to July) were satisfactory, with zero detentions. Moreover, the last PSC inspection was conducted on **12th July 2023** from Italian PSC at Livorno port with zero deficiencies, as per the figure below



Paris MoU on Port State Control

REPORT OF INSPECTION IN ACCORDANCE WITH THE PARIS MEMORANDUM OF UNDERSTANDING ON PORT STATE CONTROL'

FORM A

Name Of Ship	FREMANTLE HIGHWAY	IMO Number	9667344	Date Of Report	12/07/2023	Place Of Inspection	Livorno

☐	Next port of call informed
☐	Flag State Administration informed
☐	Recognised organisation informed

DEFICIENCIES	☒ no	☐ yes (see attached FORM B)
OUTSTANDING DEFICIENCIES***	☒ no	☐ yes (see attached FORM B)
SUPPORTING DOCUMENTATION	☒ no	☐ yes (see annex)

PORT STATE PARTICULARS			
Head Office/District Office	Compamare Livorno	Telephone	+39 0586826011
Address	Piazza della Sanita n.1 57123 Livorno (LI) dm.livorno@pec.mit.gov.it	Email	cplivorno@mit.gov.it
		Website	

Name(s) of duly authorized PSCO(s) of reporting authority	Signature	Visit Date
Marco DiDomenico	Marco Di Domenico	12/07/2023

This report must be retained on board for a period of at least three years and must be readily available for consultation by Port State Control Officers at all times.

*) This inspection report has been issued solely for the purpose of informing the master and other port States that an inspection by the port State, mentioned in the heading, has taken place. This inspection report cannot be construed as a seaworthiness certificate in excess of the certificates the ship is required to carry.

**) Masters, Shipowners and/or Operators are advised that detailed information on the inspection will be reported to the appropriate authorities and organisations and is subject to publication.

***) "Outstanding deficiencies" are listed for information only and will not be taken into account for the calculation of the Ship Risk Profile and Company performance.

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FIGURE 2-B: LAST PSC - LIVORNO INSPECTION REPORT
(Source: Submitted by Operators)

Chapter 2. CREW INFORMATION

2.1 Minimum Safe Manning

The whole ship's crew consisted of 21 persons (Indian Nationality), including the Master; therefore, effective and efficient communication between crew members was observed. All officer's documentation (including National licenses, Medical fit certificate, Panama endorsements, and STCW training certificates), presented, reviewed, examined and found in compliance with the SCTW, Flag State requirements and their positions and duties on board.

The MSM certificate has been issued from PMA, identifying the minimum competency and manning requirements. The requirements of Minimum Safe Manning at the time of the incident have been fulfilled as per the vessel crew list. The following table shows the requirements for minimum safe manning vs crew on board.

MSM Requirements		**Crew on-board as per crew list**	
Capacity / STCW / Number		Capacity / STCW / Number	
✓ Master (II/2)	One (1)	✓ Master (II/2)	One (1)
✓ Chief Mate (II/2)	One (1)	✓ Chief Mate (II/2)	One (1)
✓ Deck Officer (II/1)	One (1)	✓ Deck Officer (II/1)	Two (2)
✓ AB Seaman (II/4 or II/5)	Three (3)	✓ AB Seaman (II/4)	Three (3)
✓ O/S (VI/1)	Two (2)	✓ O/S (VI/1)	Two (2)
✓ Chief Engineer (III/2)	One (1)	✓ Chief Engineer	One (1)
✓ Second Engineer (III/2)	One (1)	✓ Engineer Officer (2nd)	One (1)
✓ Engineer Officer (III/1)	One (1)	✓ Engineer Officers	Two (3)
✓ Oilers / Motorman (III/4)	Three (3)	✓ Cook / Catering	Two (2)
		✓ ETOF	Two (2)
		✓ Fitter	One (1)
		✓ Cadet (Engine/Deck)	Two (2)

TABLE 3: MANNING DETAILS
(Source: MSMC/Crew List)

During the process of the investigation, the following were obtained/conducted:

1. Physical interviews of (Master, C/O, 3rd Deck Officer, C/E, Electrician, Bosun, Deck A/B, Deepsea Pilot & Superintendent).
2. Statement of facts from (2nd Deck Officer, 2nd Engineer Officer, 3rd Engineer Officer, 2 Deck AB, O/S, Engineer Training rating & Chief Cook).

In addition to reviewing crew members' certificates, SEA examined and found that all crew were provided with valid SEA. Crew working/resting hours were reviewed and found to align with MLC regulations.

Records for familiarisation and safety drills were examined, and it was discovered that they complied with the company's SMS policies and schedule. The accessible drug and alcohol records, along with the crew certifications and familiarisation documents, were also checked and evaluated. The rescued crew members also had an unannounced alcohol test at the hospital to which they were transferred, and they tested negative for alcohol.

2.2 General Information of the deceased Seaman

Data of the Seaman that died during the incident			
Rank:	Able-Seafarer Engine	**Caused of Death:**	Cardiac arrest
Date of birth:	15/07/1964	**Date of Death:**	26/07/2023
Nationality:	Indian	**Joined Date/Place:**	14/03/2023 - Laem Chabang
Age:	59	**Duration of SEA:**	9 months (+/- 1 month)

TABLE 4: DEAD SEAMAN PARTICULARS
(Source: SEA and coroners report)

2.3 Crewmembers Fatigue Parameters

Apart from a competent crew, a well-rested crew is essential to undertake a safe voyage or passage and an effective performance during emergencies (fire or abandon). The possibility of the crew on duty being fatigued on board M/V Fremantle Highway has been investigated as far as possible.

The records of "Hours of work or Hours of rest of seafarers" for the month of July 2023, according to the SMS form, have been examined for all crew members who have been involved in this serious marine casualty. According to the records provided, the crew involved in the casualty rested adequately, and therefore, **fatigue cannot be considered as a contributing factor**.

As per MLC 2006 following are the minimum requirements for hours of rest on board:

- 10 hours in any 24-hour period, which may be divided into no more than 2 periods, one of which shall be at least 6 hours in length, and no more than 14 hours between any consecutive periods; and
- 77 hours in any 7-day period.

2.4 Crewmembers Alcohol Test Records

The **"WALLEM SHIPMANAGEMENT LIMITED"** implements a drug and alcohol policy. As per company's policy, alcohol is not allowed on-board any vessel.

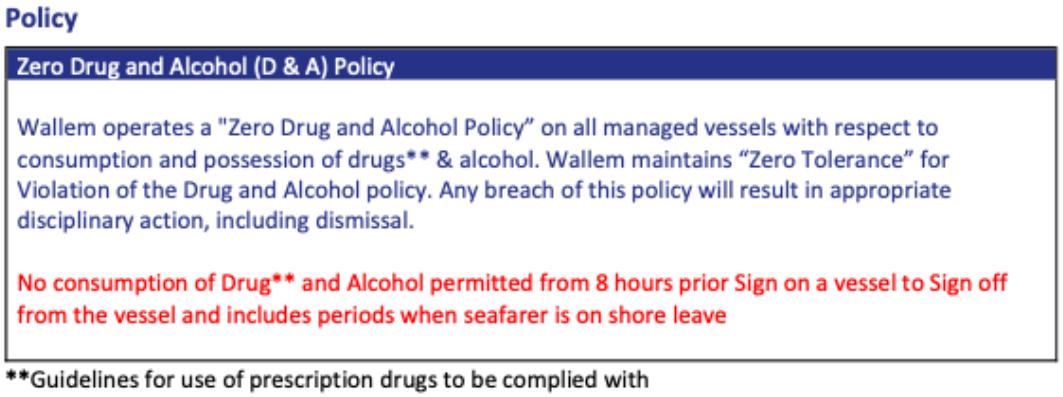


FIGURE 4: COMPANY DRUG AND ALCOHOL POLICY
(Source: Submitted by operators)

The control measures and screening program included alcohol testing for all crew on-board on a monthly basis or occasionally in the event of suspected drunk crewmembers, as well as in the event of any kind of incident to any of the vessel personnel, all persons involved must immediately be tested for the content of alcohol.

The available records of the last scheduled alcohol and drug test date from June 2023, and all crew members were found with negative results. In addition to the scheduled test, the company implements a system of unannounced "Drug and Alcohol tests." The last one was dated November 2022, and all crew members were found with negative results.

All rescued crew members have undertaken a drug/alcohol test, after the incident, with negative results.

In view of the above, the influence of alcohol consumption is unlikely to be a contributing factor towards the fire on **M/V FREMANTLE HIGHWAY.**

Chapter 3. CASUALTY DETAILS

3.1 Particulars of the Casualty

The main details of the Marine Casualty are listed below:

Item	Description
Vessel Name:	FREMANTLE HIGHWAY
Casualty Type:	Fire/Explosion in 8 Decks 6,7,8,9,10,11,12 (Accommodation deck) upper decks, Navigation Bridge Deck.
Time and date of casualty:	23:11 hrs LT / July 25th 2023 (LT = UTC + 2hrs)
Location of casualty:	**(53°46.0'N/006°41.0'E)** approximately 27 kilometers north of the Ameland Island in the North Sea.
Number of crew:	21 Crew members + 1 Deepsea pilot + 1 Superintendent.
Damages / Loss:	Cargo Decks, Bridge and Hull damages.
Number of fatalities / Injured:	**1** Crew member (59 year old A/B) / **22** injured personnel including the Deepsea Pilot and the Superintendent.
Intended track:	Vessel en-route from Bremerhaven/Germany to Suez Canal/Egypt
Course:	250°
Speed:	About 16.3 Knots

TABLE 5: CASUALTY PARTICULARS

3.2 Environmental Conditions at the Time of the Fire/Incident

The following weather information table is based on the data from weather condition reports and form data provided by operators' reports.

Item	Data
Wind Direction:	NW'ly
Wind Speed:	About force 5
Sea State:	3-4 Beaufort Index
Visibility:	Good over 5 miles
Time of Day:	Night

TABLE 6: ENVIRONMENTAL CONDITIONS
(Source: Master report)

3.3 Voyage Details

Item	Data
Port of Departure:	Bremerhaven/Germany
ETD:	25th July 2023.
Port of Arrival:	Suez Canal Egypt
Estimated average Speed:	16-17 Knots
Cargo:	3,784 (including 498 EV)

TABLE 7: VOYAGE DETAILS
(Source: Extracted from various SMS records submitted by operator)

3.4 Place where the fire started on board

The initial four Smoke Detector (SD) alarms on the night of the fire are detailed in the ALARM PRINT OUT (Below Table 8). An alarm that is received from a smoke detector is denoted by the text "SMOKE." The Zone/Address of the SD and the Position/Frame number are both included in an alarm record. Nevertheless, the output contains adequate information to determine the locations and activation times of all four alarms on **July 25th**. The final alarm is only partially legible, and the printout is not a comprehensive record of the alarms.

The below table contains the alarm details. Text that was not visible in the photographs is indicated by entries in brackets. The format of the alarm times is hh:mm. Four smoke detector lines extend the entire length of the deck space, with two on the port side and two on the starboard side. Position on the starboard side is denoted by S-S. CS-S denotes a position on the starboard side that is inboard and closer to the centerline than those designated S-S.

Zone	Address	Location	date	UTC	Frame	Position	Alarm
008	17	(No. 8 Car dk)	25/07/2023	21:10	(53)	(CS-S)	Fire Alarm
008	30	No. 8 Car dk	25/07/2023	21:11	53	S-S	Fire Alarm
008	29	No. 8 Car dk	25/07/2023	21:11	64	S-S	Fire Alarm
008	(17)	No. 8 Car dk	25/07/2023	21:11	53	CS-S	('Heavy Smoke')

TABLE 8: FIRE ALARM DATA FOR THE 25TH OF JULY 2023
(Source: MTD fire experts report)

The below figure illustrates the arrangement of the smoke detectors (highlighted red) in the area of concern on Deck 8 (red dashed line). The three SDs that were activated are denoted. The vehicles are also arranged. BMW iX1s comprise vehicles 1A and 1C. Vehicles 1B, 1D, 2A, 2B, 2C, 2D, 3A, 3B, and 3C were all BMW i7s; all BMWs were electric vehicles (EVs). The Minis M1-M6 were stowed to the port of the centerline. 3D, 4A, 4B, 4C, and 4D were Rolls Royce vehicles.

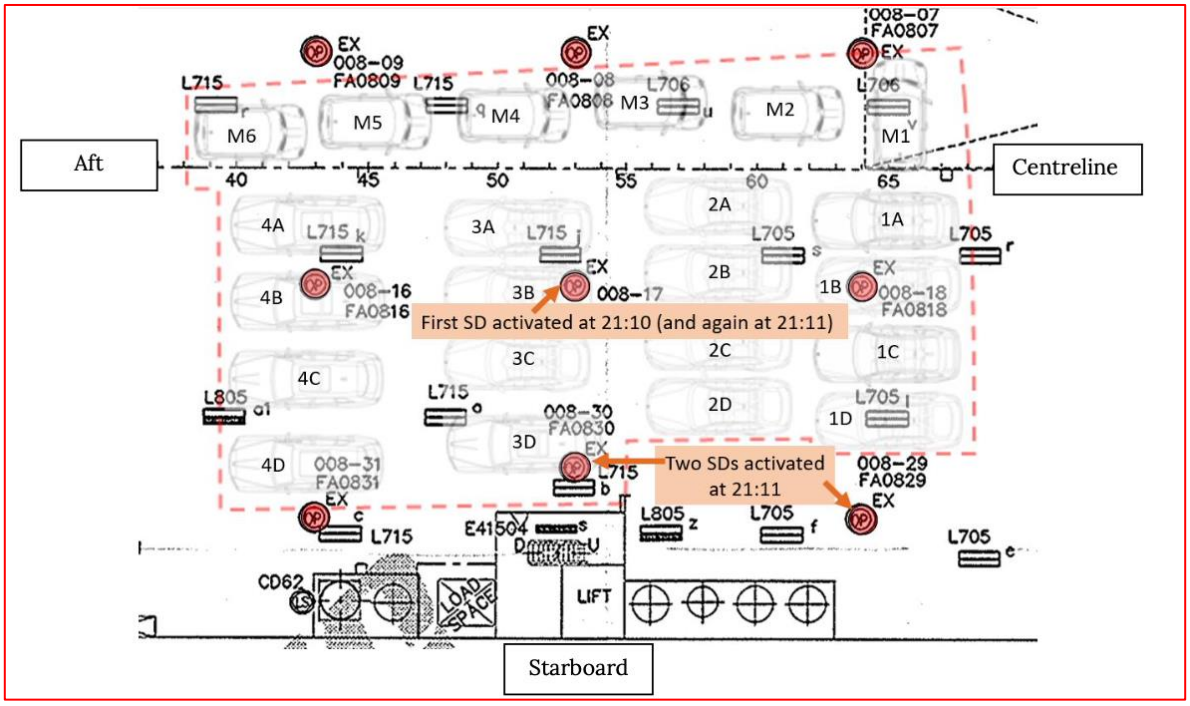


FIGURE 5: ARRANGEMENT OF SMOKE DETECTORS AND VEHICLES ON DECK 8
(Source: MTD fire experts report)

The first alarm (SD 008-17) activated at **23:10hrs LT**. This detector is central to the area of interest and suggests a fire originating close to vehicle 3B.

The second and third alarms are both set for **23:11hrs LT** and are for two SDs on the starboard side (008-30 and 008-29). The initial alarm is promptly followed by alarm 008-30 in the printout. This suggests that this SD was activated before 008-29, despite the fact that both have the same time signature. The activation of these detectors signifies the forward movement of smoke in a forward orientation and towards the starboard side. The distance between these SDs is approximately 10 meters, or eleven frames.

The entry for the fourth notification is incomplete. A reference to both F53 and CS-S is included in the part entry, which corresponds to SD 008-17. For SD 008-17, this serves as an additional alarm. We suspect that the alarm at **23:11 hrs LT** is for "Heavy smoke," as the initial notification was "Fire Alarm" at **23:10 hrs LT**.

The printout and witness testimony both indicate that the first alarms which activated were for Deck 8 Hold 4. There is good agreement between the witness testimony and the alarm printout which suggest an origin for the fire close to the second line of vehicles to starboard of the centreline. Taken as a whole, the four fire alarms (**23:10-23:11 hrs LT**) indicate a rapidly developing fire and one consistent with the eyewitness testimony.

Based on the above it can be considered that there is very strong evidence that the fire originated in a consignment of BMW EVs recovered in Deck No 8, Hold No 4.

3.5 Vessel Damaged Inspection

The subject vessel was initially attended by a "fire experts' team" consisting of an appointed fire expert, jointly with the Dutch Safety Board representative and Police officers, on the 9th of August, 2023, while she was alongside in the port of Esmshaven, The Netherlands.

The scope of the inspection o/b was to examine and report on the vessel's condition, verify the extent of damages, and gather any available data/records/evidence that could be used in order to determine the sequence of events and source of the fire.

Due to the harmful substances on board, the invesigation on board was conducted on a limited basis, under supervision and with the proper personal protective equipment. On the starboard side, the "fire experts' team" entered the vessel at the pilot entrance on the **5DK**. At the level of the bow, the flexible **6DK** was placed in the highest position. On **5DK** were mobile cranes, transfer cranes and trucks, equipped with an aerial platform stored. Parts of the floor of the **5DK** were covered with solidified aluminum, which had flowed through holes in the decks above.

FIGURE 6: TRUCKS EQUIPPED WITH AN AERIAL PLATFORM ON THE 5TH DECK
(Source: Physical inspection O/B - Fire Expert Report)

Through the stairwell in the bow of the vessel, the "fire experts' team" went to the mooring deck on the **7DK**. On the mooring deck lays an EEBD (Emergency Escape Breathing Device). From the previously received statements and interviews with the crew members, the "fire experts' team" concluded that the EEBD was left by the third officer before he jumped in the sea/water. The life rafts on the mooring deck were still in place at the embarkation stations. Inside at the **7DK**, seen from the bow, the total destruction of the stowed cars was visible, **8DK deck** came down partially and crushed several vehicles underneath.

FIGURE 7: CRUSHED VEHICLES AT 7TH DECK
(Source: Physical inspection O/B - Fire Expert Report)

The vehicles on the port side of **8DK** were still identifiable as vehicles. The vehicles on the starboard side are barely recognizable as vehicles; the destruction was enormous, and therefore, it can be considered as the area where the fire started. It was not possible for the "fire experts' team" to go between the remains of the vehicles. Sections of **8DK** were deformed and other sections had fallen down in their entirety. Traces found on sections of **8DK** such as parts that had fallen from cars, show that the collapse of certain sections of this deck was a result of the fire which developed at a later stage on **7DK.**

	
FIGURE 8: 8TH DECK PORT SIDE (Source: Physical inspection O/B - Fire Expert Report)	**FIGURE 9: 8TH DECK STBD SIDE (Source: Physical inspection O/B - Fire Expert Report)**

The vehicles on **9, 10, 11, 12DK** were also burned. Although the visible damage to the vehicles on the **12DK** differs from what is visible on the decks below. Probably a lack of oxygen, due to the huge smoke development, affected the burning process on **12DK**

	
FIGURE 10A: 9TH DECK BURNED CARS (Source: Physical inspection O/B - Fire Expert Report)	**FIGURE 10B: 10TH DECK BURNED CARS (Source: Physical inspection O/B - Fire Expert Report)**

	
FIGURE 10C: 11TH DECK BURNED CARS (Source: Physical inspection O/B - Fire Expert Report)	**FIGURE 10D: 12TH DECK BURNED CARS (Source: Physical inspection O/B - Fire Expert Report)**

The upper deck was heavily deformed by heat. After initially being convex, the upper deck collapsed. The accommodation and bridge were also completely destroyed by the fire. All possible data carriers, as well as hard copies of records and reports on the bridge, were destroyed.

	
FIGURE 11: UPPER DECK DEFORMED (Source: Physical inspection O/B - Fire Expert Report)	**FIGURE 12: BURNED EQUIPMENT ON THE BRIDGE (Source: Physical inspection O/B - Fire Expert Report)**

There was hardly any damage below **5DK**, other than the pollution (such as foam or water residue) that occurred during the fire extinguishing operation. **4DK** and the engine room were visited during the survey and were found in intact condition.

	
FIGURE 13: 4TH DECK (Source: Physical inspection O/B - Fire Expert Report)	**FIGURE 14: E/R (Source: Physical inspection O/B - Fire Expert Report)**

3.6 VDR

Chapter V of the International Convention for the Safety of Life at Sea (SOLAS), regulation 20, specifies VDR carriage requirements. Cargo ships larger than 3,000 gross tons, and all passenger ships regardless of tonnage, must be equipped with a VDR. The VDR for a cargo ship larger than 3,000 gross tons, constructed before July 2002, maybe an S-VDR.

3.6.1 VDR Specifications

Maker	**Japan Radio Co.**
Model	**JCY - 1800**
Retrieved Data Duration	**Audio –** From 21:00 UTC (23:00LT) **on 25/07/2023 to** 09:26 UTC (11:26LT) **on 26/07/2023** **Log/NMEA –** From 22:30 UTC (00:30LT) **on 20/07/2023 to** 09:26 UTC (11:26LT) **on 26/07/2023**
Installation Compliance	*VDR system as installed is in compliance MSC Circular 163 (78), IMO Resolution MSC 333(90).*

3.6.2 VDR Analysis

The **VDR** assessed the period of vessel operation/passage when the fire broke out on **25th July 2023**, when the vessel in navigation in coastal waters, left Bremerhaven in Germany

en route for Egypt, with weather cloudy, visibility good and during night. The time frame of VDR data analyzed from **25.07.2023 @ 23:00 UTC to 26.07.2023 @ 11:26 UTC**; all "times" are based on VDR DATA, which have been recorded in **VDR display time.** The below **Figure** provides/illustrates on charts (**charts are non-type-approved and for illustration purposes only**) the sequence of events of fire, salvage operation and towing of Fremantle Highway.

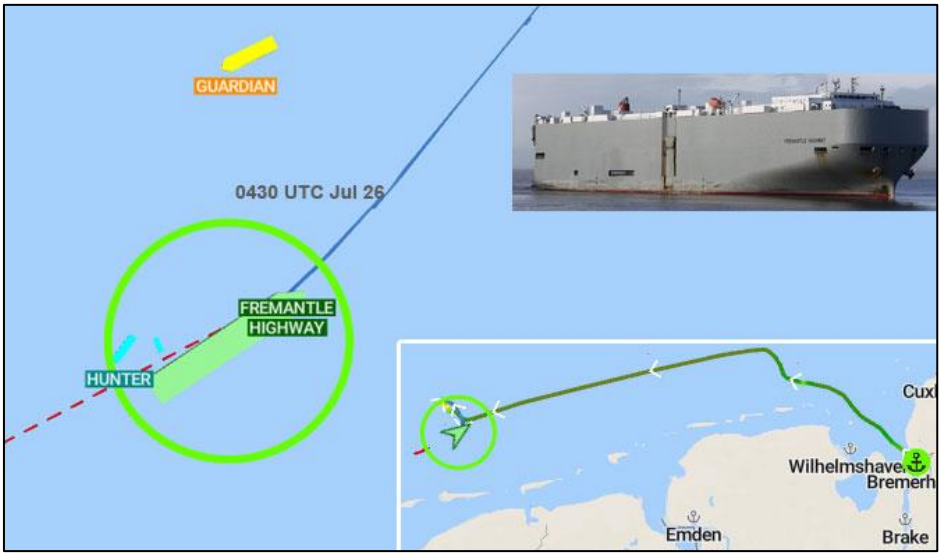


FIGURE 15A: Fremantle Highway; at 04:30 UTC 26/7/2023

FIGURE 15B: Fremantle Highway; at 15:20 UTC 26/7/2023

FIGURE 15C: Fremantle Highway; at 05:30 UTC 27/7/2023

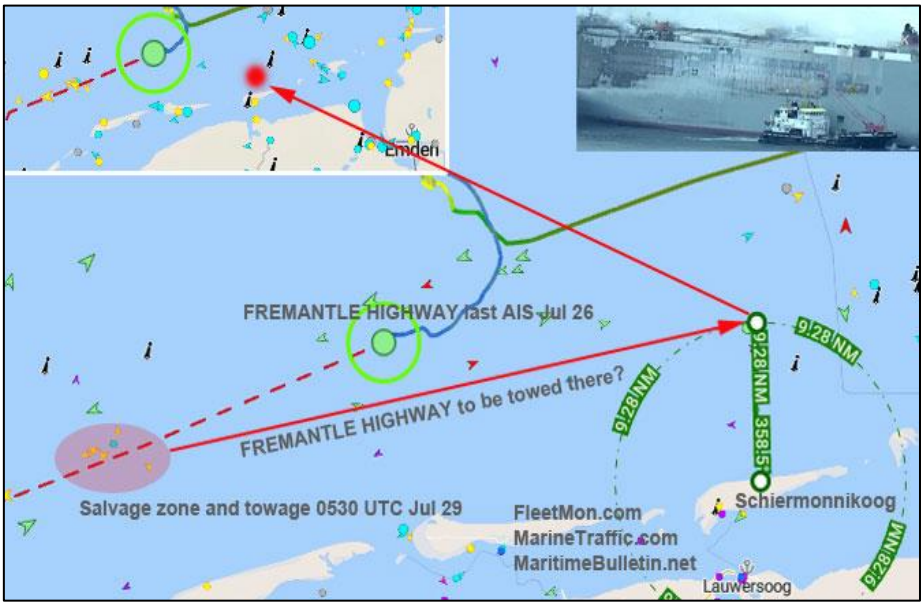


FIGURE 15D: Fremantle Highway; summary of sequence of events from 26/7/2023 - 29/07/2023

Audio Recording Location:

Below **Figure** describes each microphone's location on the bridge; there were four microphones mounted internally to the bridge.

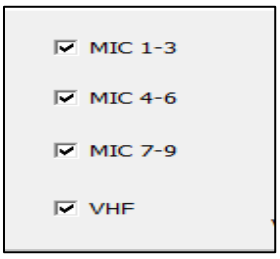


FIGURE 16: STATUS OF MICROPHONES (Extracted from VDR software playback)

Recorded Duration:

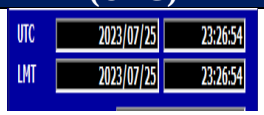
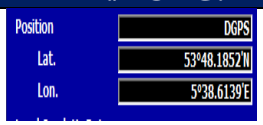
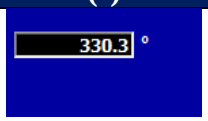
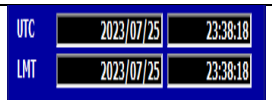
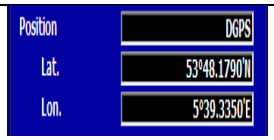
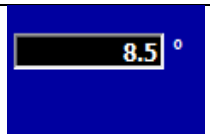
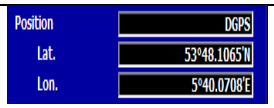
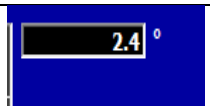
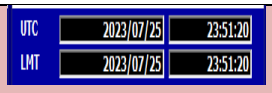
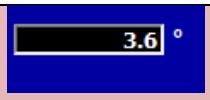
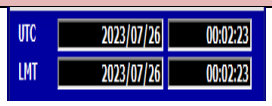
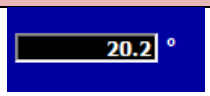
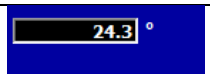
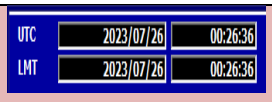
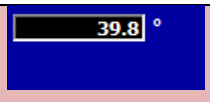
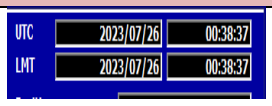
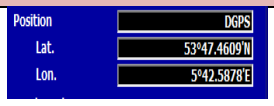
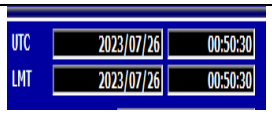
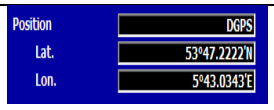
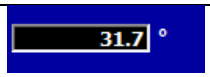
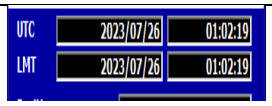
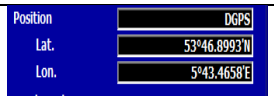
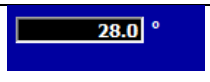
Approximately **12 hours, 00 minutes and 00 seconds** of audio were recovered from the VDR capsule. As stated previously, the recording began on **July 25th July 2023 at 23:26:38 UTC** and ended on **July 26th July 2023 at 11:26:32 UTC.**

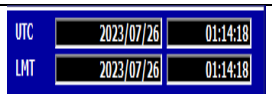
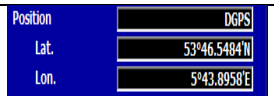
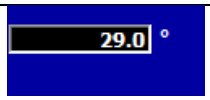
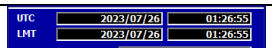
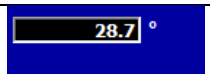
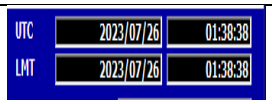
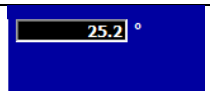
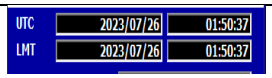
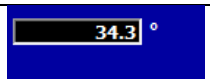
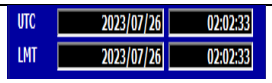
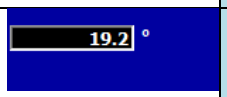
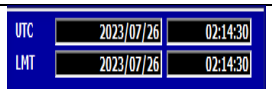
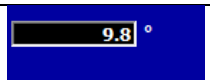
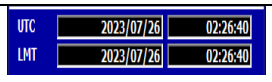
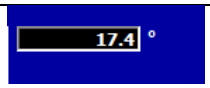
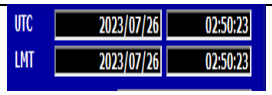
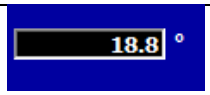
FIGURE 17: VDR STAR/END RECORDING PERIOD (Extracted from VDR software playback)

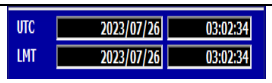
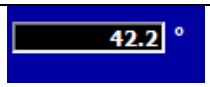
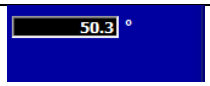
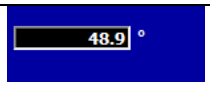
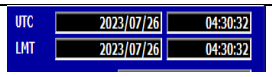
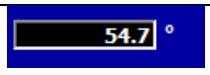
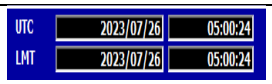
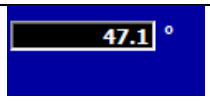
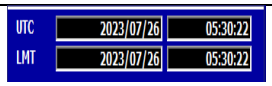
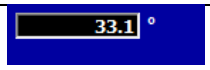
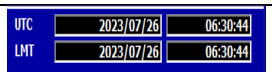
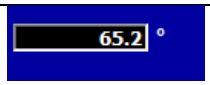
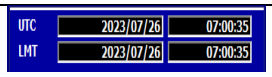
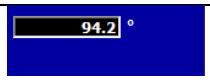
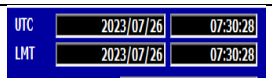
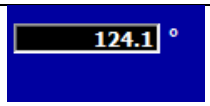
Audio Quality as the Voyage Progress:

While analyzing the VDR Data, most of the crew conversations were accurately and easily understood. The audio quality was **Good.**

VDR Audio Transcription/TimeLine – Fire Events:

EVENT	DATE/TIME (UTC)	POSITION LAT./LONG.	HEADING (°)	REMARKS
1				Start of recording, Vessel was adrift, No any alarms. Noisy bridge, from bridge team talking other language (Indian) than English and VHF.
2				Several Alarms relevant propulsion control; Noisy bridge, from bridge team and conversation with coastguard on VHF. Coastguard called vessel.
3				Several Alarms relevant propulsion control; Noisy bridge, with the bridge team conversation.
4				**FIRE alarm, (Generic, Smoke/Heat) & Water lever alarm, Fire doors alarm.**
5				It was told by the vessel through VHF to shore that the LSA are not assessable and their opinion is to send a helicopter to evacuate the ship.
6				Several Alarms relevant propulsion control. Arrangements to evacuate the ship, with coastguard.
7				**FIRE alarm, (Generic, Smoke/Heat) & Steering Gear alarm, Door alarm.**
8				Several Alarms relevant propulsion control. **MAIN POWER FAILURE alarm.** Preparations to evacuate the ship.
9				Several Alarms relevant propulsion control. **MAIN POWER FAILURE alarm.**
10				Several Alarms relevant propulsion control. **RADAR STAND BY.**

11				Several Alarms relevant propulsion control. **RADAR STAND BY.**
12				Several alarms related Steering Gear, Door alarm, **Fire Alarm Generic/Smoke, Heat RADAR STAND BY.**
13				Several Alarms relevant propulsion control. **RADAR STAND BY.**
14				Several Alarms relevant propulsion control, Door alarm **RADAR STAND BY.**
15				Several Alarms relevant propulsion control, Door alarm **RADAR STAND BY.**
16				Several Alarms relevant propulsion control, Door alarm **RADAR STAND BY**
17				Several alarms related Steering Gear, Door alarm, **Fire Alarm Generic/Smoke, Heat RADAR STAND BY.**
18				Several Alarms relevant propulsion control, **RADAR STAND BY.**
19				Several Alarms relevant propulsion control, **RADAR STAND BY.**

20				Several Alarms relevant propulsion control, **RADAR STAND BY.**
21				Several Alarms relevant propulsion control, **RADAR STAND BY.**
22				Several alarms related Steering Gear, Door alarm, **Fire Alarm Generic/Smoke, Heat RADAR STAND BY.**
23				Several Alarms relevant propulsion control, **RADAR STAND BY.**
24				Several Alarms relevant propulsion control, **RADAR STAND BY.**
25				Several Alarms relevant propulsion control, **RADAR STAND BY.**
26				Several Alarms relevant propulsion control, **RADAR STAND BY.**
27				Several Alarms relevant propulsion control, **RADAR STAND BY.**
28				Several Alarms relevant propulsion control, BACK-UP POWER FAIL alarm. **RADAR STAND BY.**
29				Several Alarms relevant propulsion control, BACK-UP POWER FAIL alarm. **RADAR STAND BY**

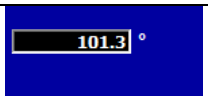
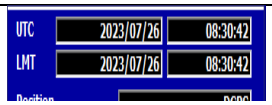
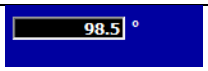
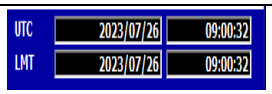
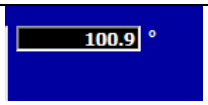
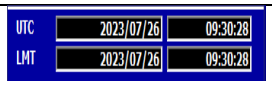
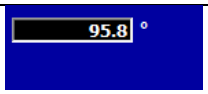
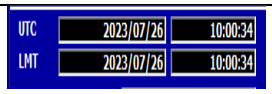
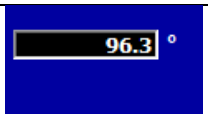
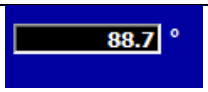
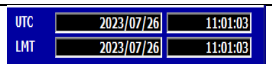
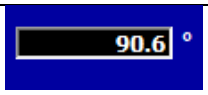
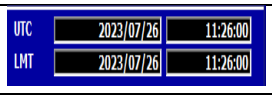
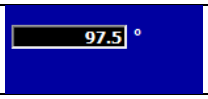
30				Several Alarms relevant propulsion control. **RADAR STAND BY.**
31				Several Alarms relevant propulsion control. **NO RADAR IMAGE.**
32				Several Alarms relevant propulsion control. **NO RADAR IMAGE**
33				Several Alarms relevant propulsion control, BACK-UP POWER FAIL alarm. **NO RADAR IMAGE.**
34				Several Alarms relevant propulsion control, BACK-UP POWER FAIL alarm. **NO RADAR IMAGE.**
35				Several alarms related Steering Gear, Door alarm, **Fire Alarm Generic/Smoke, Heat NO RADAR IMAGE.**
36				Other system alarm, BACK-UP POWER FAIL alarm. **NO RADAR IMAGE**
37				END of recording.

TABLE 9: AUDIO TRANSCRIPTION/TIMELINE – FIRE EVENTS (Source: VDR)

Note: for further details regarding the vessel readings/data for radar, Alarm status and wind speed/direction, refer to VDR playback data.

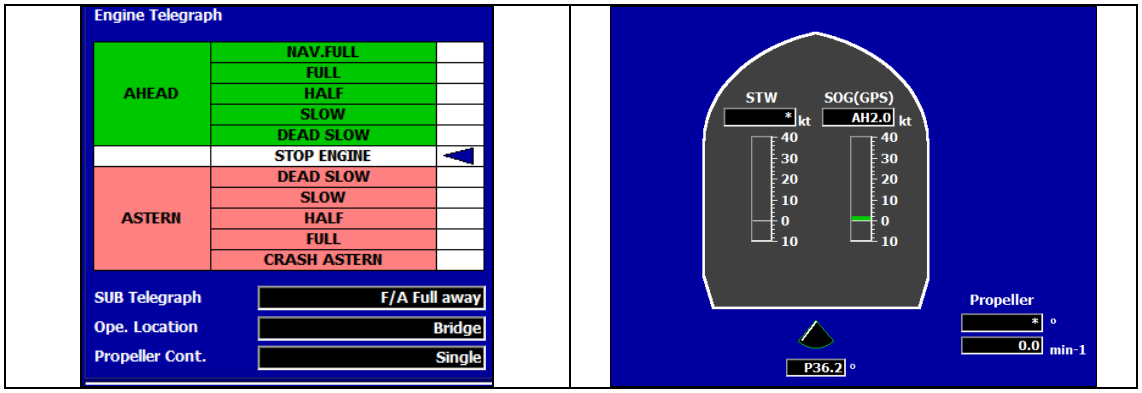


FIGURE 18: ENGINE TELEPGAPH (Extracts from SVDR playback software)

Remarks: During the recording period the Engine was stopped and vessel's speed was around 2.0 knots (drifting).

FIGURE 19: RUDDER INDICATIONS (Extracts from SVDR playback software)

Remarks: During the recording period the vessel's rudder was stuck at P 36.2 °

The list below presents the most crucial timelines meticulously derived from reliable and accurate VDR data.

July 25th, 2024 (Initial Notification)

1. **2310hrs LT:** Fire alarm activated by first sensor on deck 8 (Reference: Fire Alarm print out).
2. **2311hrs LT:** Fire alarm activated by more adjacent sensors (Reference: Fire alarm print out)
3. **23:43hrs LT**: the Deepsea Pilot reports to the Coast Guard:

FH: *Netherlands coast guard, the Fremantle Highway.*
NLCG: *Fremantle Highway, the Netherlands coast guard. Good evening sir, how can I help you?*

FH: *For your information, eh this vessel is suffering a fire at the moment. Eh, it would appear that an EV car battery ignited and slowing down and moving clear of the Terschelling TSS to anchor. Eh, just for your information at the moment we're preparing all our firefighting equipment to eh, fight this fire, but at the moment our intention we clear the traffic lane and probably anchor.*

NLCG: *Eh, Fremantle Highway, Netherlands coast guard, that is understood eh, sir so far, how many persons are on board and what is your position?"*

4. **23:44-45hrs LT**: the Deepsea Pilot reports to the Coast Guard:

NLGC: *What type of vessel are you, and do you have any cargo?*

FH: *a fully loaded car carrier, and it is an EV, is it, an Electric Vehicle battery fire on board.*

NLGC: *Okay Sir, and the fire, is it in the engine room, is it on one of your decks?*

FH: *On a cargo deck.*

NLGC: *Okay Sir, eh, at this moment, eh, what are your intentions?*

FH: *eh, at the moment we're pulling out of the traffic lane, and well anchor whilst they continue to fight the fire."*

5. **23:46hrs LT:** the Deepsea Pilot reports to the Coast Guard:

NLGC: *Fremantle Highway, eh, Sir, you stated that you wanted to drop the anchor, at this moment you are right on top of a cable, so do not drop the anchor at this moment. Eh, question: do you require any assistance from our side?*

FH: *That's all received on the anchoring, I'm still slowing down. I'll give you a call before I anchor to confirm the position is ok.*

At the moment no assistance is required, they are deploying the fixed fire fighting systems onboard.

NLGC: *Okay Sir, understood.*

Subsequent developments on July 26th, 2023

1. **01:30hrs LT:** The vessel advised the NLCG that the fire was spreading portside

toward the accommodation.

2. **01:42hrs LT:** The crewmembers were instructed by the Master to be prepared for abandonment or rescue.
3. **01:37hrs LT:** The master gives the order for vessel abandonment.
4. **01:39 hrs LT:** Bridge is instructed by NLCG to change to channel 67.
5. **01:44 hrs LT:** The vessel advised the NLCG that the vessel is loaded with EV on cargo decks No.7 to 10.
6. **01:46hrs LT:** The vessel was advised that the rescue boats would be alongside in approximately 30 minutes.
7. **01:55hrs LT:** The vessel informed NLCG of the loss of power and that they had an STBD list of 10 degrees, most probable due to the cargo shift in 8DK.
8. **01:58hrs LT:** The vessel advised the NLCG that access to LB is impossible.
9. **02:03hrs LT:** The vessel advised the NLCG that LSA are inaccessible and that a helicopter for evacuation is required.
10. **02:13hrs LT:** The vessel confirmed to the NLCG that all crew are gathered on the bridge deck and are ready to evacuate with the helicopters.
11. **02:15hrs LT:** The vessel advised the NLCG that the 3rd Engineer officer was on the poop deck aft, and he was unable to go to the bridge. The NLCG requested that the vessel assess the area and advise if a helicopter could approach. The reply from the vessel was negative, and then the NLCG asked the vessel to confirm with the 3rd Engineer that he could jump into the sea/water. The reply from the vessel side was positive.
12. **02:30hrs LT:** The rescue boat advised the 3rd Engineer to jump into the sea/water.
13. **02:39hrs LT:** The vessel advised the NLCG that the rest of the crew members were located in the bridge area and ready to jump into the sea/water. The NLCG replied that the helicopters would be in the rescue area in 45 min.
14. **02:55hrs LT:** The NLCG advised the vessel that if the crew would jump from the port bow side (30m height), one by one, the rescue boat would pick them up. Master agreed to do so.
15. **03:16hrs LT:** The rescue boat from NLCG advised the vessel to cease crewmembers from jumping from the vessel due to the excessive height involved.

3.7 Ship Cargo Details

3.7.1 Loading plan or Stowage plan

On **25th July 2023**, the vessel sailed from Bremerhaven/Germany to Singapore via Suez Canal/Egypt, voyage Number 76Z, loaded with **3,784 units/vehicles (including 498 EV)** as per the below-provided stowage plan. The 2nd Deck Officer planned Voyage plan No 76Z between Bremerhaven/Germany and Suez Canal/Egypt, reviewed it by the Deepsea pilot, and approved it by the Master.

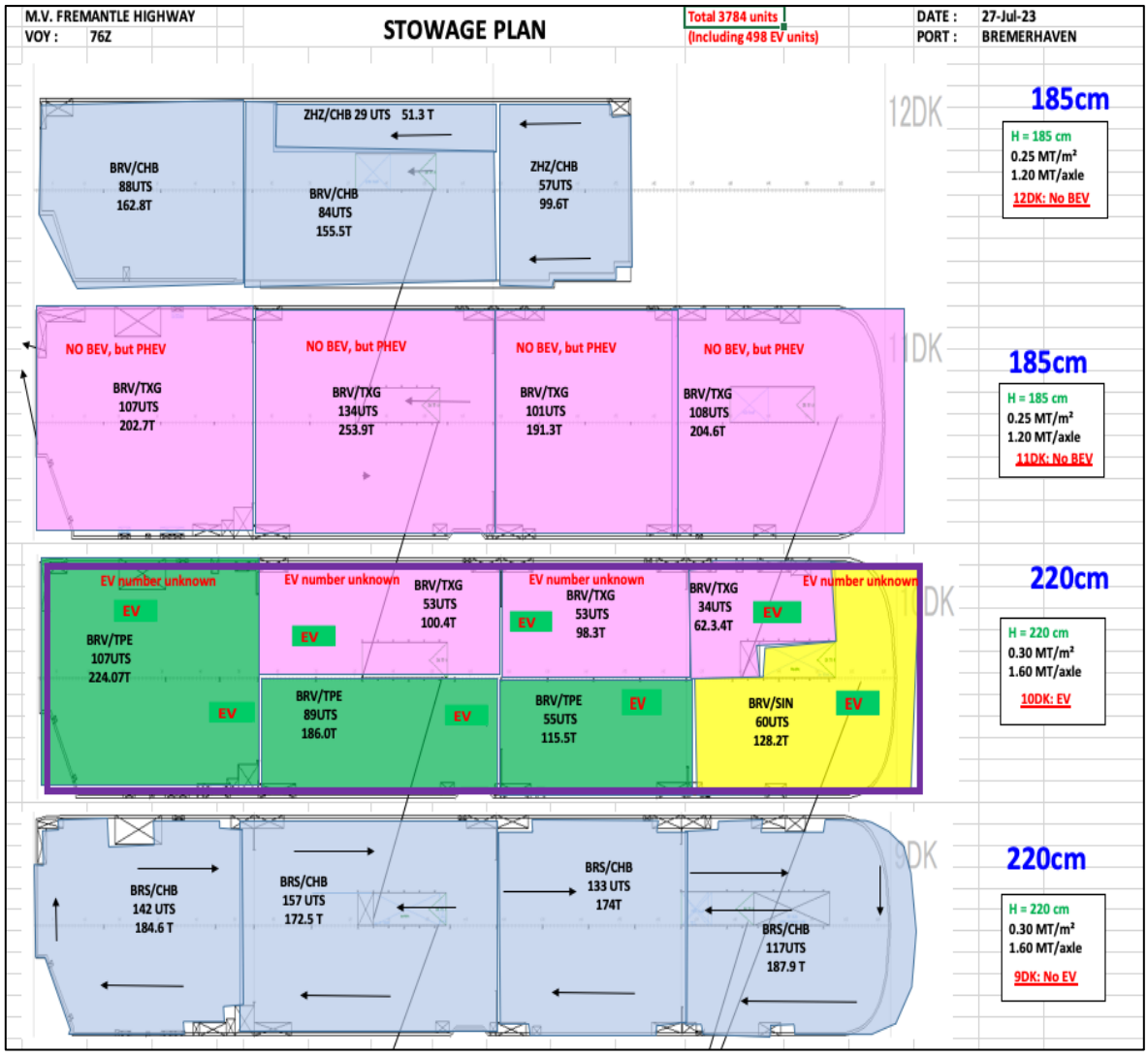


FIGURE 20A: STOWAGE PLAN PART A
(Source: Submitted by Operators)

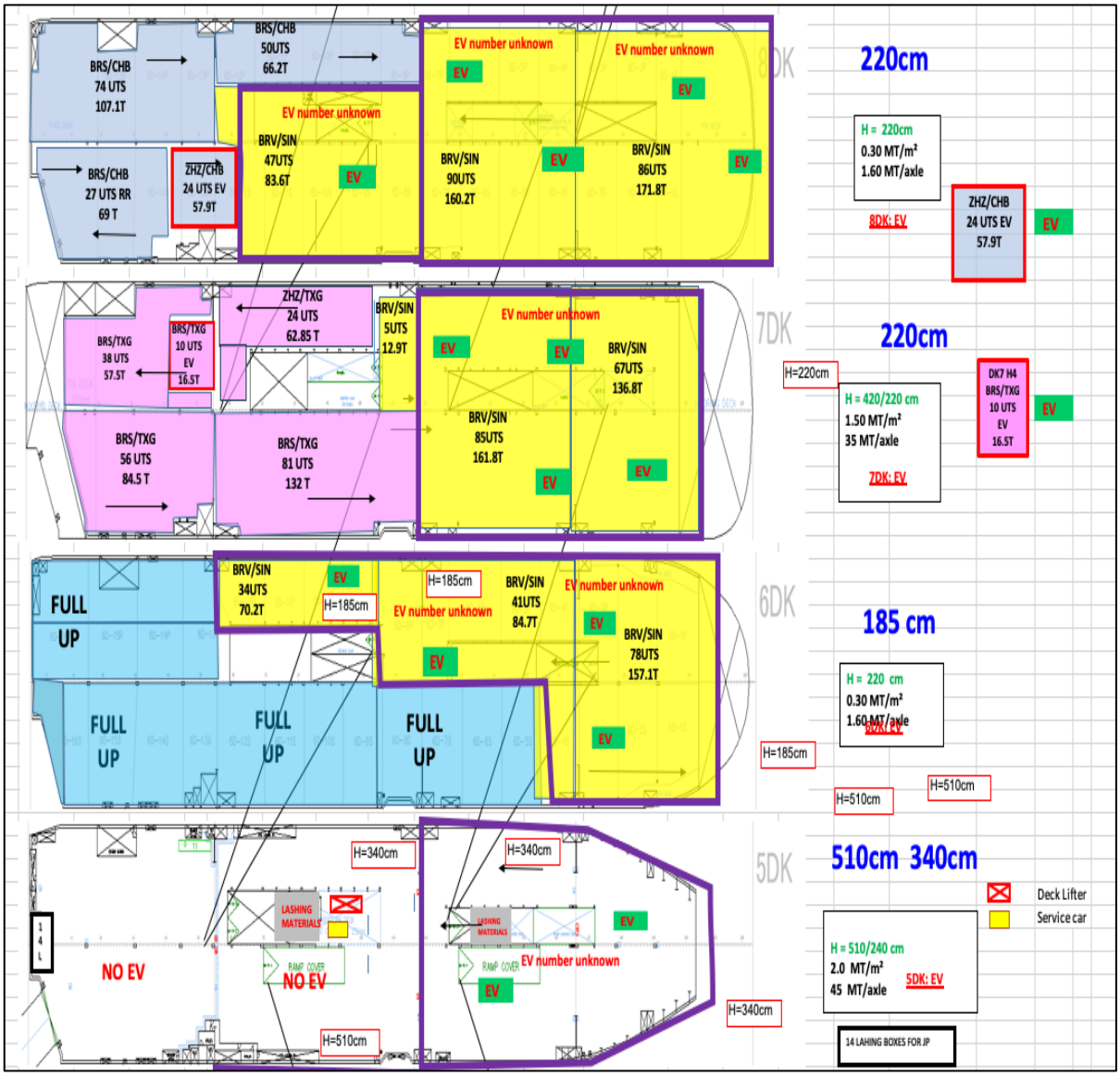


FIGURE 20B: STOWAGE PLAN PART B
(Source: Submitted by Operators)

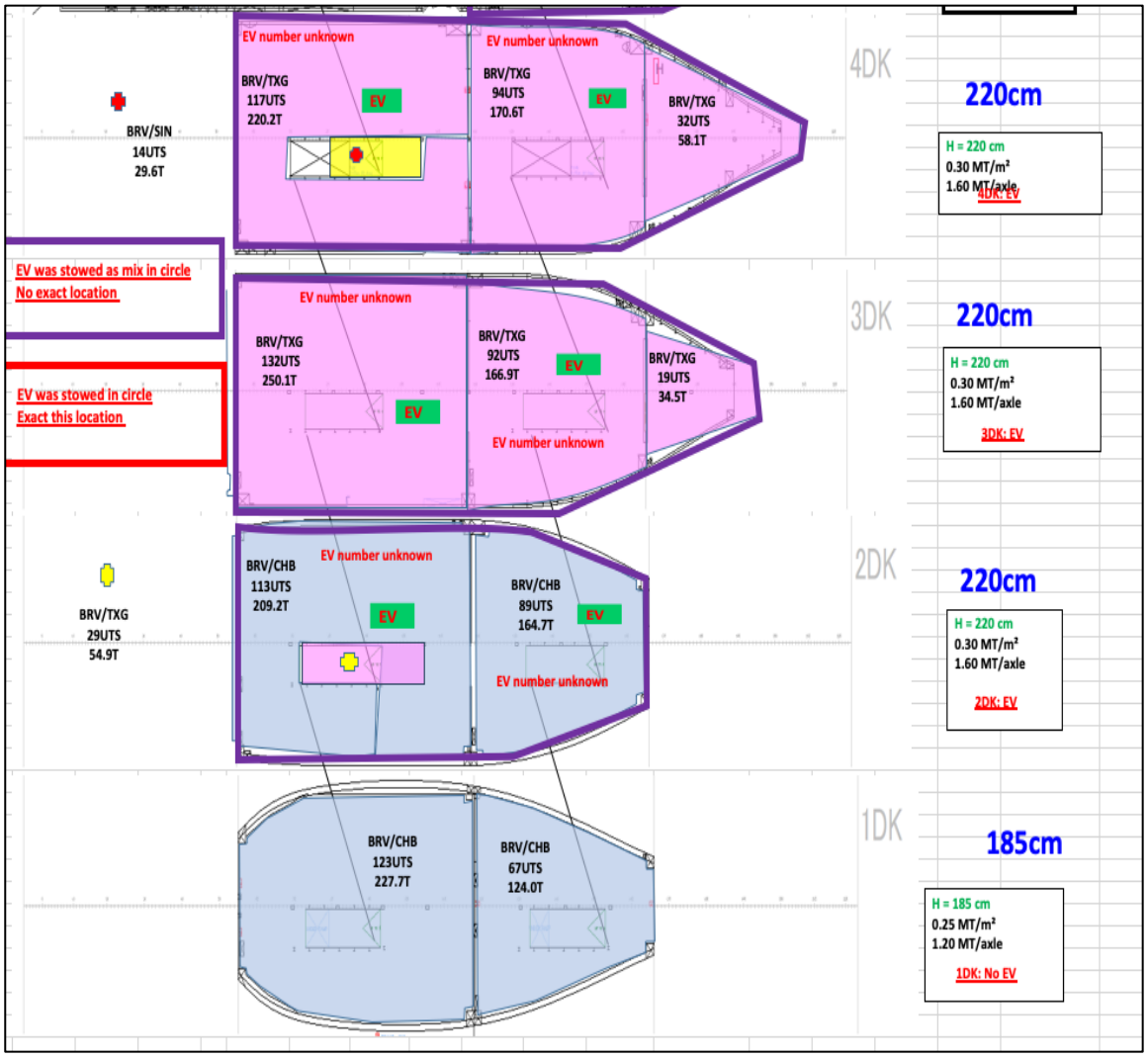


FIGURE 20C: STOWAGE PLAN PART C
(Source: Submitted by Operators)

A joint meeting was conducted with the fire specialists in attendance during their visit to the ship on October 18th and 19th, 2023. Representatives from nine interested parties, not including the DSB, attended the meeting on October 18th. All attendees reached a consensus on a specific area of interest. The area of interest was determined based on the eyewitness testimony of the location of the initial fire and the first fire alarm on the fire

panel (Deck 8, Hold 4). The fire alarm printout, which was later discovered to have survived, confirmed the accuracy of the area of interest, as the first fire alarms came from the detectors directly above (EV's in) that area. The area of interest was defined as twenty-two vehicles that were stowed at the Deck 8 Hold 3/Hold 4 boundary. A margin of error was applied to the forward, aft, port, and starboard directions.

According to the stowage plan provided (for the area of interest) Deck No 8, the following can be summarised.

1. The Stowage plan for Deck 8, after loading at Bremerhaven is shown in **Figure 20B**. BMW Group cargo is indicated to fill all four holds of Deck 8 with the exception of some Audis and VWs forward in Hold 1.
2. According to this document 27 RR units (we understand RR to denote Rolls Royce) were loaded in Bristol for discharge in Chiba. These were stowed aft on Deck 8 (starboard side).
3. A group of Electric Vehicles (EVs), (Figure 3, red box) were stowed on Deck 8 to starboard of the centreline at the Hold 3/4 boundary. These EVs were loaded in Zeebrugge for discharge in Chiba.
4. We consider that the 74 Unit and 50 Unit blocks on the port side relate to Minis, based on the number and weights of the units and the fact they were loaded in Bristol, again for discharge in Chiba.
5. The BMWs loaded in Bremerhaven completed the loading of Holds 2 and 3 on Deck 8, and some of Hold 1.

3.8 Search and Rescue Operation

According to the Master statement and VDR audio data, the Deepsea pilot communicated and coordinated with the shore rescue facilities NLCG/JRCC.

In particular, based on the statement of a witness provided by the crew members, the Deepsea pilot was assigned in charge of the vessel navigation and handling communication with the rescue center to assist the Master in focusing on the fire o/b, always under the agreement and instruction of the Master.

According to Deepsea's pilot statement, once the situation became critical, he suggested to the Master not to waste time by Mayday but instead to contact the NLCG directly. Indeed, the Deepsea pilot contacted the NLCG by VHF (Initially in channel 23 and afterwards in channel 67), at 23:43hrs LT and advised them that the vessel was suffering a fire o/b, and that it would appear that an EV car battery ignited. It must be highlighted that at 23:44-45hrs LT, the Deepsea pilot reported to the NLCG that "the vessel is a fully loaded car carrier", and it is an EV…an electric vehicle battery fire on board, and that they were trying to control the fire by deploying the fixed fire extinguishing system (foam).

Once it was clear to the Master that crew members could not extinguish the fire o/b and that the fixed foam system had been deployed without any positive extinguishing effect on the fire, the evacuation plan started to be implemented. Initially, the Master intended to use the vessel LB/LR to evacuate the vessel. However, the fire o/b was spreading very rapidly, and in a few min, the area of LB/LR was full of smoke and the presence of extremely high temperatures (heat); consequently, the area could not be accessed.

The crewmembers, excluding the 3rd Engineer Officer who was in the E/R, promptly gathered in the area of bridge and monkey island, choosing the spots with less smoke. They were equipped with their lifejackets and immersion suits, demonstrating their readiness to evacuate the vessel.

On the **26th of July 2023**, at approximately **02:00 hrs LT**, the Deepsea pilot advised the NLCG that assistance for evacuation was requested.

During the rescue operation, the following units were deployed from the NLCG

1. Two NLCG Rescue Boats (KNRM)
2. One NLCG Dash 8 patrol aircraft
3. Two NLCG helicopters
4. One Support vessel

Rescue boats (KNRM) Rescue Operation:

The first rescue unit to approach (at about **02:00 hrs LT**, on **26th July 2023**) the vessel was a patrol aircraft Dash 8 supervising the rescue area/scene, measuring the heat at the vessel, and communicating/coordinating with the vessel. At about **02:00hrs LT, on 26th July 2023**, one **NLCG rescue boat (KNRM)** arrived at the rescue scene. A second rescue boat arrived shortly after **03:00hrs LT.**

As indicated above, the fire was spreading very rapidly, and the vessel was full of smoke, making breathing and vision very difficult for crewmembers. Most of the crew members were in bad shape, affected by the smoke and vomiting. At this point, the "panic" started to spread among the crew members since it was unclear how to evacuate the vessel.

Some of the crew members tried to get down to the lower decks, the bow mooring area, and they couldn't because of the smoke. The handrails and the decks were very hot, so they decided to return back to the bridge.

The crewmembers had the following two alternatives.

- Jump to the sea/water from a height of 30 meters.
- Wait for the helicopters

The first to jump into the sea/water was the 3rd Engineer Officer **(on about 02:30 hrs LT)**. Initially, he was in the E/R assisting C/O with the ballasting operation. When the 3rd engineer was instructed to evacuate the E/R, he tried to use the escape trunk from the

control room up to the 12DK, and he started climbing up to about 10DK. Then, the ladder was too hot to hold because of the fire inside the cargo areas, so he decided to go down and use another escape trunk from the steering gear up to the poop deck on the 7DK. At that time, this area was free from smoke. The 3rd Engineer Officer advised the Master that he could not reach the bridge, and he was instructed to stay at the poop deck. He prepared himself with a life jacket and immersion suit. After approximately one hour (at about **02:30 hrs LT**),, he jumped into the sea/water (from a high of approximately 12-15 meters) and was picked up by the rescue boat crew.

The rest of the crewmembers were located on the bridge, and the height to jump into the sea/water was approximately 30 meters. Since the 3rd Engineer was picked up from the rescue vessel, and taking into consideration that at that time it was not clear to the Master how long it would take for the helicopters to reach the rescue area, in coordination with the rescue boats and aircraft, he advised the crewmembers that the ones who had lifejackets and/or immersions suites and were willing to jump, could proceed and reach the rescue boats, which were already in the fwd part of the vessel to pick them up.

At this point, it should be highlighted that no evidence was provided that the crewmembers were advised for the following.

- They have to position their bodies in a certain way for the 30 meters jump into the sea/water.
- They should not carry any additional weight during the jump
- That they should have an appropriate size immersion suit, the vessel was provided with only one size immersion suits (universal for body weights 50-150 Kg).
- The life jacked should not be donned but held in hands.

Six crewmembers in total, under the fear of smoke/fire and heat and since it was uncertain to them when the helicopters would arrive, they thought that if they stayed o/b they would die, therefore they decided to jump into the sea/water, from the bridge and they were picked

up from the rescue boat. The jumpers had some difficulty getting in a position to jump because they had to climb over the handrails first; they were wearing immersion suits, which restricted mobility.

When they were picked up, they were unconscious. It was reported that all of them had a violent landing at sea/water in a flat position, and some had backbags with them. Therefore, the commander of the rescue boats realised that the "jumping" operation was very risky. Crewmembers were not trained to jump from such a high and, therefore, it was not an appropriate manner to evacuate the vessel; considering that the helicopters were underway, he advised the vessel to instruct crew members to stop jumping into the water/sea.

Unfortunately, one of the crew members, an A/B (who was also the first jumper), jumped into the sea/water from the bridge; regardless of the efforts of the medic, he passed away. The official report provided by the local authorities indicates a death during/after the jumping overboard of a 59-year-old man from a great height (30 meters). In the beginning, the lack of obvious injuries makes death by drowning a good possibility, considering it was likely that he swallowed a lot of seawater after jumping and but it was eventually determined that the victim died due to cardiac arrest.

	
FIGURE 21A: LIFE JACKET USED BY CREW JUMPED INTO SEA/WATER	**FIGURE 21B: LIFE JACKET USED BY CREW JUMPED INTO SEA/WATER**
	
FIGURE 22A: IMMERSION SUITS USED FROM CREW JUMPED INTO SEA/WATER	**FIGURE 22B: IMMERSION SUITS USED FROM CREW JUMPED INTO SEA/WATER**

Helicopter Rescue Operation:

Shortly after midnight on **July 26th, 2023**, both NLCG rescue helicopters were scrambled due to a fire on the M/V Fremantle Highway, sailing north of the Dutch island of Ameland.

The JRCC directed both SAR Helicopters to collect the Marine Intervention Reaction Group "MIRG", specialist firefighters, from Rotterdam. Based on the instructions received, the helicopters departed from Den Helder and Midden Zeeland bases and rendezvoused at the Rotterdam helicopter base.

By the time the helicopters were in Rotterdam, the "MIRG.NL" were informed that the fire o/b was escalating in intensity and stated that it was unclear whether they would be able to deploy the "MIRG-Team."

Based on the above new information received with respect to the condition of fire o/b, the SAR commanders of the helicopters liaised with the JRCC and it was agreed to return the helicopters to a position close to the incident in case evacuation was needed/requested. "MIRG" were embarked as soon as they were ready and the first helicopter departed for Den Helder base. Shortly after the departure of the first helicopter from Rotterdam, the situation o/b the vessel was reported as extremely deteriorated; the fire was spread on various decks o/b, and the crew access to the LB/LR stations was not possible. JRCC directed the helicopters to cancel "MIRG" deployment and commence evacuation operations as soon as possible.

Following the latest instructions, the first helicopter landed at Den Helder, "MIRG" disembarked and performed a running rotor refuel. The second helicopter, which was already in Rotterdam, disembarked "MIRG", and both helicopters started their flight to the rescue scene.

Once the helicopters arrived at the location of the vessel **at 3:24hrs LT**, it was noticed that the rescue operation was hazardous, with thick toxic smoke obscuring the rescue scene, with ongoing fire and the obvious threat of explosion.

Despite all the risks/hazards described above, the first helicopter began the evacuation at about **3:24 hrs LT** by lowering its winchman to the burning vessel and winching up nine crewmembers (the operation was completed at about **3:41 hrs**).

FIGURE NO 23: (NINE CREWMEMBERS RESCUED FROM 1ST HELICOPTER)
(Source: Photograph taken from NLCG rescue helicopter)

The second helicopter first proceeded to deploy the medic to the KNRM vessel with the most seriously injured crewmember and then rescued the remaining seven crewmembers from the vessel (rescue operation started at **3:55hrs LT** completed at **4:05hrs LT**.

FIGURE NO 24: (SEVEN CREWMEMBERS RESCUED FROM 2ND HELICOPTER)
(Source: Photograph taken from NLCG rescue helicopter)

Once all 16 crewmembers were rescued, the medic from on board KNRM lifeboat was still tending to the injured persons and he requested further medical equipment, which the helicopter deployed.

FIGURE NO 25: (2ND HELICOPTER DEPLOY MEDICAL EQUIPMENT TO KNRM)
(Source: Photograph taken from NLCG rescue helicopter)

The rescue operation was completed and the rescued crew members + the two non-regular crew members were transferred to the local hospital for the first aid and further medical treatments. Unfortunately, the fatally injured crew member that jumped to sea, regardless the efforts of Medic passed away.

Chapter 4. FIRE FIGHTING CERTIFICATION AND EQUIPMENT

The main scope of the casualty on M/V Fremantle Highway was a fire in the cargo holds. Therefore it is considered of vital importance during the process of the casualty investigation to examine and verify that the FFE available o/b was in good condition, ready to be used and that crewmembers were familiar with the FEE operation.

The vessel was provided with an approved Fire and Safety plan, and the main FFE equipment can be summarized in the below table.

FIRE FIGHTING APPARATUS		DP:2(5KG),1(40Kg), FOAM:254(9LTRS),FOAM:2(45 LTRS), PORTABLE FOAM APPLICATOR: 1 (20L+20L SPARE TANK)
ENGINE RM.	:	
CARGO HOLD & ENG RM	:	HIGH EXPANSION FOAM,
ACCOMMODATION/CAR DECK/EXPOSED DECK	:	DP:221(5KG), FOAM: 25(9LTRS), PORTABLE FOAM APPLICATOR: 5 (20L+20L SPARE TANK), WATER FOG APPLICATOR:9
FIRE HYDRANTS:		DECK+CARDECK: 94(40) & 15 (65),ENG ROOM:6(65)
HELICOPTER WINCHING	:	DP: 2(23KG), CO2: 1(23KG),PORTABLE FOAM APPL
FIRE DETECTORS	:	OKI DENKI BOHSAI FIRE ALARM SYSTEM
ENGROOM : SMOKE DETEC: 32, TERMAL: 5, FLAME 8 / HULL SMOKE DETEC: 769		
ENGINE ROOM LOCAL		HYPERMIST SYSTEM

FIGURE 26: SUMMARY TABLE OF FFE AVAILABLE O/B
(Source: Submitted by operators)

As per SMS records, scheduled routine safety checks have been implemented/performed satisfactorily, and FFE/LSA equipment has been reported to be in good condition, without defects and in sufficient numbers, in line with vessel certificates. In addition, during crew interviews, crewmembers declared that the FFE equipment was ready for use and properly deployed and that there was no shortage of FFE or LSA equipment. From the outcome of the casualty, it was confirmed that the fixed fire extinguishing systems o/b were satisfactorily deployed, although there was no positive extinguishing effect on the fire, and crewmembers were found with adequate PPE (immersion suits and lifejackets). However, as previously indicated the vessel was provided with only one (IMO type approved) size immersion suit (universal for body weights 50-150 Kg), with the last mandatory external annual inspection dated 09/07/2023. However, taking into consideration that the body shape of Indian crewmembers is, in general, slim, a consideration could be raised concerning the "safety fit" of the immersion suit.The FFE's last mandatory external annual inspection was conducted on 09/07/2022 and has been found to be in satisfactory condition. Additionally, the last verification from an external body related to the operation of FFE/LSA was conducted by the classification society of the vessel, NKK, on 11/10/2022 and has been found to be in good order.

消防系统检修证明
SERVICING CERTIFICATE FOR FIRE FIGHTING APPLIANCES

靠泊港口 Inspection Port	舟山 ZHOU SHAN	检修证明编号 Cert. No.	20220103030082
船名 Name of Ship	FREMANTLE HIGHWAY FREMANTLE HIGHWAY	船旗国 Flag	巴拿马 PANAMA
船籍港 Port of Reg.	巴拿马 PANAMA	IMO No.	9667344

	名称 (Designation)	数量 (Quantity)	下次检修日期 (Date of next inspection)
☐	CO2系统（CO2 System）		
☑	泡沫系统（Foam System）	1	2024-07-08
☐	干粉系统（Dry Powder System）		
☐	卤代烷系统（Halon System）		
☐	自动喷淋系统（Sprinkler System）		
☐	固定式压力水雾灭火系统（Fixed pressure water-mist fire extinguishing system）		
☐	七氟丙烷灭火系统（Heptafluoropropane fire extinguishing system）		
☐	探火和报警装置（Fire detection and alarm system）		
☐	厨房灭火系统(Fire extinguishing systems for protection for galley)		
☑	手提式灭火器（Portable fire extinguisher）	265	2023-07-08
☑	车推式灭火器（Non-portable fire extinguisher）	6	2023-07-08
☐	救生艇用空气瓶（Air cylinder of lifeboat）		
☑	消防员装备（Firemen's Outfit）	4	2023-07-08
☐	医用氧气装置（Medical oxygen device）		
☑	应急逃生装置（EEBD）	9	2023-07-08
☐	其他消防系统（Other fire extinguishing system）		

操作员 Inspector: 于洪玖 YU HONGJIU
质检员 Supervisor: 胡太省 HU TAI SHENG
技术负责人 Quality Manager: 孙先锋 SUN XIAN FENG
签发日期 Date of issue: 2022-07-09
检修站（盖章）Service Station(Stamp): 青岛美海船舶服务有限公司舟山分公司 Qingdao E-TECH Marine Equipment Service Co., Ltd ZhouShan Office

声明：
1、此证明附有经本公司签署的含有产品证书编号、出厂编号的相应检验/测试记录。
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2.The captioned company will take legal responsibility for the validity and authenticity of this certificate.
地址： 舟山市定海区新港开发区大成路32号 Add: No.32 dacheng Street, xingang development zone, zhoushan
电话(Tel)： 18653268839 传真(Fax)： 0580-8134289 邮箱(Email)： qdetech@qdetech.com

FIGURE 27: ANNUAL INSPECTION REPORT OF FFE
(Source: Submitted by operators)

Chapter 5. DESCRIPTIONS OF FACTS

5.1 Events Prior to the Incident

Bremerhaven, Germany, was the last port the subject vessel called before the fire incident, and it was there that it conducted operations related to loading and unloading vehicles. At approximately **14:00hrs LT**, the cargo operation was satisfactorily finished without any delays, and at approximately **15:00hrs LT**, the ramp was secured. As per the loading/stowing plan provided by the operators/charterers (all records on board were burned or damaged by the fire), the vessel was loaded with **3,784 new vehicles** (including **498 electric vehicles**) and special construction machinery.

The deck/engine department implemented the SMS "prior departure" checklist, and no navigational or safety equipment defects were reported. The engine room was as normal in UMS; however, since the vessel was operating in SECA (the vessel had to consume LS-MGO or low-sulfur fuel), the engine department personnel had a routine of visiting the E/R and topping up the service tank.

The vessel sailed out on the **25th of July 2023** at about **15:00hrs LT.** At about **20:00hrs LT, same day,** the vessel dropped the pilot, and the Deepsea pilot took over the role, which was like an assisting role. The vessel started its journey towards Brixham, the next point where the Deepsea pilot would be dropped, and the vessel would proceed to the Suez Canal/Egypt.

Prior to the vessel's departure, a superintendent captain from the shore management company joined the vessel. His role was to oversee the vessel's operations, conduct periodic sailing trips, safety audits, and checks through the company procedures. The crewmembers were expected to perform emergency drills in his presence, and he was to provide feedback on their performances. Therefore, according to the best maritime practice, he should be considered as "passenger", and he should not have any kind of role/duties during vessel

navigation or emergency scenarios.

In addition, the vessel was also provided with a Deepsea pilot. The Deepsea pilot joined the vessel at Portbury in Bristol and went with her to Zeebrugge for cargo operations and then to Bremerhaven for cargo operations. The intention was then to proceed back to the North Sea and the English Channel to Brixham, where he would disembark, and the ship would continue its voyage on the Suez/Egypt and to Singapore. The role of the Deepsea pilot is purely advisory to the Master and Deck officers, and he does not have any interference with the vessel's operation or safety checks. It is common practice that the Deepsea pilot will discuss with the Master and C/O the voyage plan and he will indicate his suggestions, and it is the Master's final decision on how the vessel will proceed. Moreover, it is common practice, provided that the Master agrees, for the Deepsea pilot to assist watchkeeping officers, if they wish, by communicating with the pilots.

Moreover, as per shore-based management company SMS procedures, there is a safety and fire patrol every two hours. The safety patrol visually checks the cargo holds/decks (as far as possible) and other vessel areas. They also check the temperature of the cargo holds/decks with thermal equipment.

The last patrol was conducted at **21:00hrs LT** on **25th July 2023** and everything was reported to be normal.

5.2 Sequence of Events

On **July 25th, 2023**, at approximately **23:00hrs LT**, the vessel was in a location (53 46 N 006 41 E). The electrician and the engine cadet were in E/R, while the 3rd deck officer and one AB were on the bridge in compliance with the watchkeeping schedule. The 3rd Deck Officer acknowledged the fire alarm on the bridge at **23:11hrs LT** by using the indication panel. The alert signal mentioned area **8DK, hold 4.** Simultaneously, he called the Master, who arrived at the bridge, assumed command, and gave the 3rd Deck Officer and the AB orders to investigate the suspected area.

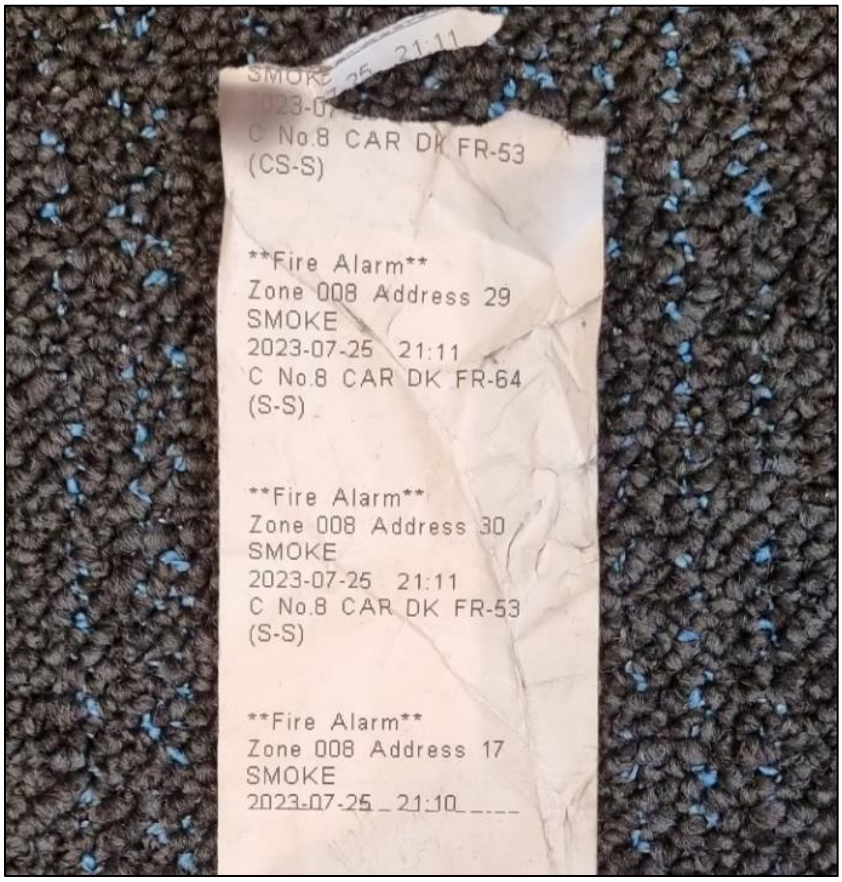

FIGURE 28: PRINT OUT OF FIRE ALARM
(Source: Obtained from a crewmember overall/immersion suit by the Dutch police on July 26th, 2023 and shared with the DSB/PMA)

The 3rd Deck Officer and AB did not take any special FFE/PPE with them, except a radio (to communicate with the bridge), since they considered that there was a high possibility of a smoke sensor malfunction rather than an actual fire. As per crewmembers' statements, they did have some false alarms in the past. However, when they arrived at **8DK**, they reported to the bridge that they saw smoke and flames coming from one or more (electric) vehicles while looking inside the deck.

The Master continuously sounded the main fire alarm and announced that this was not a drill. Due to the alarm, the Deepsea pilot was also alerted and attended to the bridge; the Master requested the Deepsea pilot to take over the vessel's navigation so he could focus on the fire and firefighting teams. They discussed/agreed with the Deepsea pilot that they had to alter the vessel's course in order to clear the TSS and an underwater gasline that needed to be avoided; they also agreed to slow down the engine. The vessel started to alter her course to the stbd and started taking the wind from the bow.

FIGURE 29A: AIS PAST TRACK FROM 25-26/07/2023
(Source: AIS)

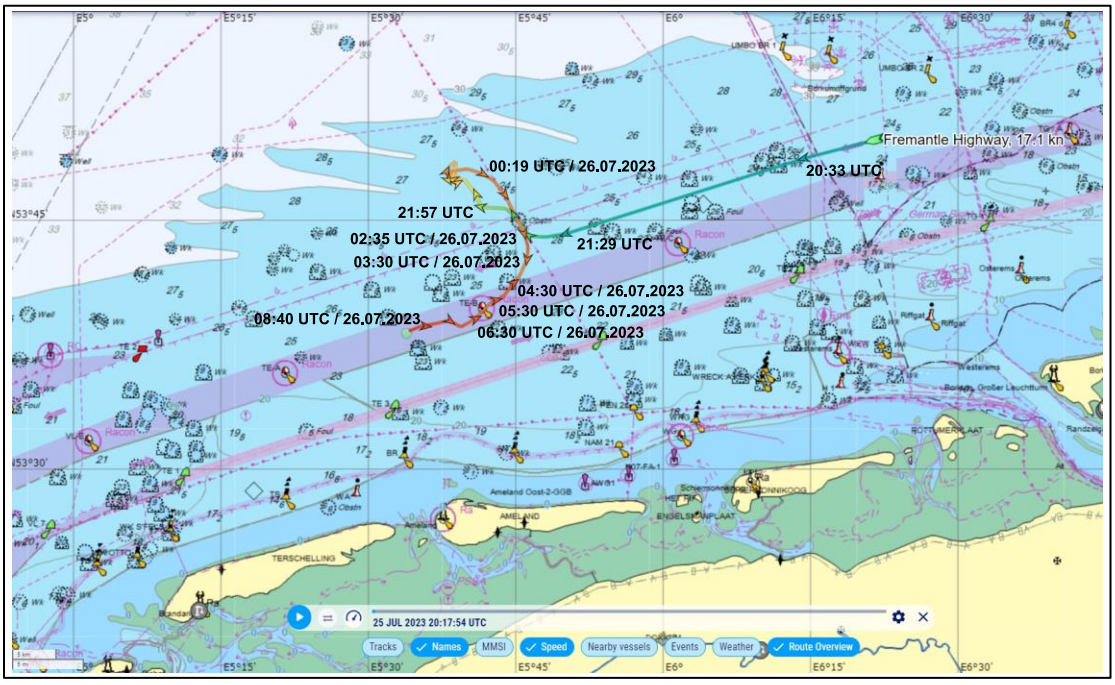

FIGURE 29B: AIS PAST TRACK FROM 25-26/07/2023
(Source: AIS)

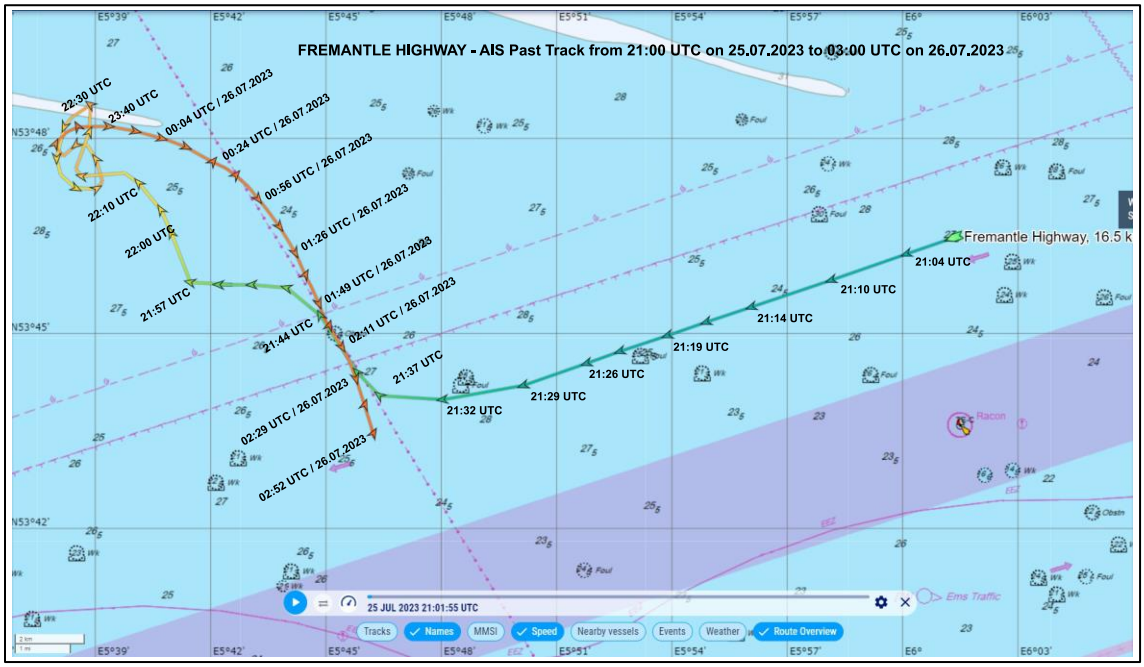

FIGURE 29C: AIS PAST TRACK FROM 25-26/07/2023
(Source: AIS)

Hearing the fire alarm, the crewmembers acted in line with the shore-based company emergency procedures and mustered to their muster stations on the 12DK, aft of the accommodation. At the muster station, the emergency team gathered on the starboard side, the first aid team (Chief Cook and Messman) on the port side, and the support team in the center. The support team will do boundary cooling, bring spare BA bottles, and prepare backup firefighters. Operating ventilation flaps is also part of the support group's role.

The C/O (in charge of the emergency team) and the bosun went to the 8DK to further investigate the area. Immediately, he observed very heavy smoke rapidly increasing, and the bridge was immediately informed. The Master requested the emergency team to assess the overall condition and to advise if they could attack the fire using the fire extinguishers. The C/O replied that the smoke was thick and dark, and they could not approach the unit in flames. In addition, he indicated that he assumed that the unit on fire is probably an EV because the area where he sees the flames is where EVs are located. C/O with the emergency team, unable to act, returned to the muster station and did a head count. Afterwards, he reported to the Bridge on a radio how many people were accounted for at the muster. The Master confirmed a fire and said to prepare for firefighting and boundary cooling. C/O then confirmed to the crewmembers that the fire alarm was coming from 8DK. He confirmed he could see smoke down below from looking down the ramps. Each top deck, 7 through 12, is connected with ramps in the same locations.

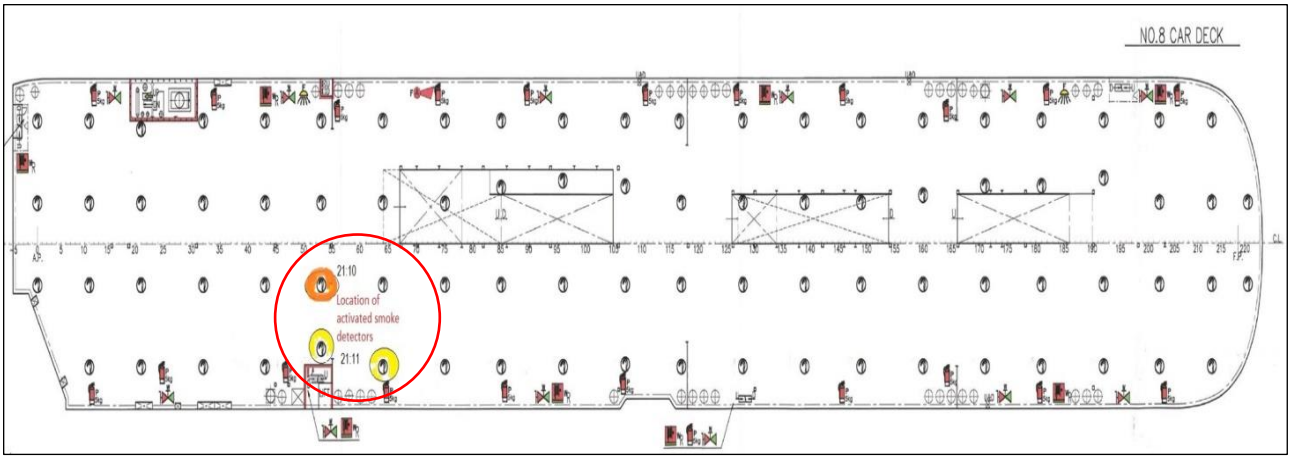

FIGURE 30: LOCATION OF ACTIVATED SMOKE DETECTORS
(Source: Submitted by DSB)

The fire support team was instructed to do the boundary cooling. The C/O instructed the support team to start boundary cooling from aft - meaning the poop deck. C/O clarified that the initial fire alarm was from 8DK, hold 4. The support team brought spare BA bottles and started preparing hoses for boundary cooling on the starboard side of the 12DK. By then, the fire support team could already see from the access to the 12DK that there was smoke. The firefighters were preparing to enter the 12DK, so the hoses were ready on the outside for boundary cooling. There is no other outside area to boundary cool further down, except from aft.

The fire support team proceeded aft down the starboard side of the 12DK; they did not take any equipment with them; they were expecting to use hoses down on the poop deck 7DK. They went aft around the stern to the port aft corner. The staircase there leads straight down to the poop/mooring deck. On the way down the starboard side, they could already see smoke on deck, coming from the port side over the top of the weather deck.

They had to pass through the stairwell by the elevator on the starboard side but did not see anything. There was no smoke from starboard vents.

The fire support team opened the 12DK. Heavy smoke was inside, which immediately came out into their faces. It was a surprise to find that it was full of smoke; it was so heavy they could not breathe for some time. This was within 10-11 minutes of the original alarm, at about **23:21 hrs LT**. The fire support team leader closed the door immediately. It was clear that they could not proceed further. They immediately returned to the muster station, and the Master was informed accordingly.

At this point, and based on the feedback that the Master received from the fire teams, it was clear that fire teams with portable fire extinguishers and hoses could not extinguish the fire and that the fixed fire extinguishing system (foam) should be deployed. Therefore, the Master instructed the C/E and the electrician to prepare the foam system for activation, and at the same time, the 3rd Engineer Officer was instructed to go to the engine room to relieve the electrician who was down because of the fuel transfer. At the same time, the

Master informed/agreed with the Deepsea pilot to alter (as much as possible) the position of the vessel course to avoid smoke going to the bridge.

Since the foam system was about to be activated, the engine department (3rd Engineer Officer) was also instructed to start a second generator to have adequate power for the water pumps/fans used by the foam system. Before activating the foam system, the C/O instructed the fire team to check the vents in the cargo areas to be in the open position. The vessel has vent fans along each side down to the various cargo holds. They are all ventilation, but some are used as purging vents in the event that foam is put in.

Once the engine and deck departments reported to the Master that all necessary checks had been performed and that they were on standby for the activation of the foam system, the Master ordered the foam system, zone C (also covering 8DK), to be placed on. The activation of the foam system on the subject vessel goes through a certain sequence towards the final part of the activation. The foam system consists of zones A, B&C. The electrician successfully started all the blowers of the foam system and reported them to the bridge accordingly.

FIGURE 31: FOAM SYSTEM PANEL
(Source: Photograph taken by electrician)

Once the foam system started (on about **23:31hrs LT**), the fire teams reported an increase in smoke, most probably coming out of the vent. At the same time, various explosions could be heard from the cargo decks. One explosion was stronger than the others and caused the 12DK to be deformed.

Adding to the chaos, the crew reported hearing distinct 'banging' sounds from the cargo area. Given the intense fire and high temperatures in the cargo areas, the car secure devices, made from synthetic material, were severely damaged or destroyed. This meant that the vehicles were now free to move and collide with each other and the cargo holds/deck structures, posing a significant threat.

As a direct consequence of the foam system activation, water surfaces formed within the cargo decks. This, coupled with the potential movements of loose cargo/vehicles, caused the vessel to list at a significant angle (10 degrees), on about **01:22hrs LT**. The Master promptly instructed the C/O to correct the list. The C/O, equipped with a BA set, proceeded to the ballast control panel. Simultaneously, the 3rd Engineer Officer, who was in the process of evacuating the E/R, was called back to switch the operation of the Ballast pumps to manual, enabling the C/O to correct the list. The list was successfully corrected by pumping into the healing tank. To further enhance the vessel's stability, which was slightly down by the head at the time, the C/O filled the three after-peak tanks.

With the exemption of the 3rd Engineer Officer in the E/R, the crewmembers congregated around the bridge, trying to avoid the smoke. The overriding information coming to the Master was that the smoke was generated dramatically quickly, and crewmembers couldn't see what was happening. Several crewmembers tried to look inside the cargo decks to see what was happening and evaluate the fire; however, they couldn't see past the smoke. According to the Deepsea pilot statement, on about 01:55hrs LT 26th July 2023 the vessel at this stage was without propulsion, so manoeuvring the vessel was impossible. Generators were still working; therefore, the accommodation area was with electrical power.

Reviewing the vessel plans and in line with crewmembers' statements the cable pipes from the bridge to the engine room were passing along the top of 12DK, therefore it is possible that during the explosion and deformation of 12DK, the cable pipes were damaged the signal lines were cut and that tripped the main engine.

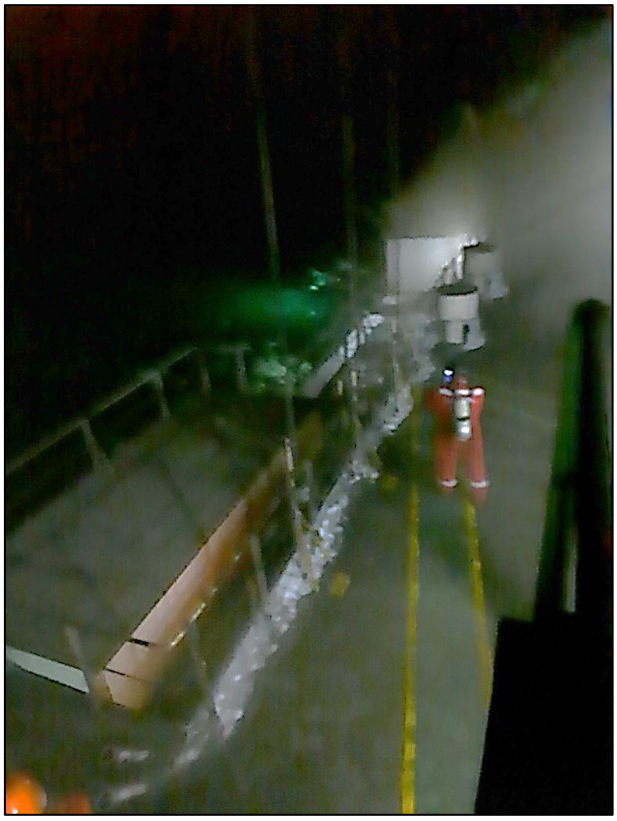

FIGURE 32: FOAM ACCUMULATED PORT/FISH PLATE
(Source: Photograph taken from electrician)

In order to ensure that the foam was deployed, the Master instructed the 3rd Engineer officer, who was at E/R, to check the foam concentrate tank in the steering gear flap. The 3rd Engineer Officer reported that when the foam system when started, the gauge on the tank was $14m^3$, and the reading was now indicating $1m^3$. In addition to that, the foam system was running for approximately 40 min, and foam could be observed coming out of

the cargo decks. Master concluded that the foam was released and instructed the 3rd Engineer officer to stop the pump. However, it was also observed that the foam did not have any positive extinguishing effect on the fire.

3rd Engineer Officer also mentioned that when he got to the poop deck the goose necks on the afterpeak tanks were overflowing, since the ballast pump was still running. The overflowing of the tanks considered to have a positive effect on fire providing boundary cooling which the support team would have been doing anyway.

Communication with the shore-based management company/operators:

As per crewmembers' statements, confirmed during the Master interview, the person who conducted the shore-based company was the superintendent. It seems that he was the communication link between the DPA and the vessel. In particular, he continued to advise the DPA about the fire status o/b, and at the same time, he was the one passing the DPA guidelines/instructions to the Master.

At this point, it should be highlighted that his role o/b was as "Passengers," and therefore, he should not have been assigned duties during this emergency scenario. Moreover, he was just for a couple of hours o/b, and therefore, he was not familiar with the vessel in order to assist. It should also be noted that for the Master, this was his first time appointed as a commander, and consequently, he has limited experience as a Master.

5.3 ISM procedures

5.3.1 Drills Procedures

One important aspect that was reviewed and analyzed during the casualty investigation was the shore-based management company training system implemented, the crewmember's preparedness to act on emergency scenarios, and their performance during the fire and abandonment. To evaluate the effectiveness of the crew members' training system o/b, the SMS emergency procedures manual was reviewed. In particular, it was found that the SMS provides procedures for the fire and abandon scenarios and additionally provides guidelines (in line with the industry best practices) for the carriage of EV.

Furthermore, records of drills, particularly abandon and fire drills, were examined, and it has been found that drills have been executed in line with SOLAS requirements and as per the vessel drill schedule. In particular, the last fire and abandon drill was conducted as follows.

- Engine room fire, fire in chemical locker 15th July 2023
- Cargo hold fire 17th June 2023
- Abandon ship 7th July 2023

The SMS form "Emergency Drill Evaluation" was also reviewed. It has been noted that the drills were conducted effectively, crew performances were found satisfactory, and crewmembers were found to be familiar with the vessel's emergency procedures and LSA/FFE equipment. However, it should be highlighted that the records of fire drills in the cargo hold do not make any reference to fire scenarios/guidelines involving EV.

Close	vessel	FREMANTLE HIGHWAY	Abandoanship Drill on 30 June 2023	Emergency Procedure Checklist 24 - Abandon Ship Procedures	At Sea	Krishnendu Sengupta
Close	vessel	FREMANTLE HIGHWAY	Abandon Ship Drill on 07 July 2023	Emergency Procedure Checklist 24 - Abandon Ship Procedures	At Livorno Anc	Krishnendu Sengupta
Close	vessel	FREMANTLE HIGHWAY	Abandon Ship Drill on 18 march 2023	Emergency Procedure Checklist 24 - Abandon Ship Procedures	At Sea	Krishnendu Sengupta
Close	vessel	FREMANTLE HIGHWAY	ABANDONSHIP DRILL - 04/03/2023	Emergency Procedure Checklist 24 - Abandon Ship Procedures	At sea	Krishnendu Sengupta
Close	vessel	FREMANTLE HIGHWAY	ABANDONSHIP DRILL - 18/02/2023	Emergency Procedure Checklist 24 - Abandon Ship Procedures	At sea	Krishnendu Sengupta
Close	vessel	FREMANTLE HIGHWAY	ABANDONSHIP DRILL ON 22/04/2023	Emergency Procedure Checklist 24 - Abandon Ship Procedures	AT SEA	Krishnendu Sengupta
Close	vessel	FREMANTLE HIGHWAY	ABANDONSHIP DRILL- 11/02/2023	Emergency Procedure Checklist 24 - Abandon Ship Procedures	At sea	Krishnendu Sengupta
Close	vessel	FREMANTLE HIGHWAY	ABANDONSHIP DRILL- 14/01/2023	Emergency Procedure Checklist 24 - Abandon Ship Procedures	At sea	Krishnendu Sengupta
Close	vessel	FREMANTLE HIGHWAY	ABANDONSHIP DRILL- 26/01/2023	Emergency Procedure Checklist 24 - Abandon Ship Procedures	At sea	Krishnendu Sengupta
Close	vessel	FREMANTLE HIGHWAY	ABANDONSHIP DRILL- 27/05/2023	Emergency Procedure Checklist 24 - Abandon Ship Procedures	DRIFTING	Krishnendu Sengupta
Close	vessel	FREMANTLE HIGHWAY	ABONDONSHIP DRILL 10JUNE 2023	Emergency Procedure Checklist 24 - Abandon Ship Procedures	AT SEA	Krishnendu Sengupta
Close	vessel	FREMANTLE HIGHWAY	ABONDONSHIP DRILL 24 JUNE 2023	Emergency Procedure Checklist 24 - Abandon Ship Procedures	AT SEA	Krishnendu Sengupta
Close	vessel	FREMANTLE HIGHWAY	ABONDONSHIP DRILL ON 06 MAY 2023	Emergency Procedure Checklist 24 - Abandon Ship Procedures	AT SEA	Krishnendu Sengupta
Close	vessel	FREMANTLE HIGHWAY	ABONDONSHIP DRILL ON 29 APRIL 2023	Emergency Procedure Checklist 24 - Abandon Ship Procedures	AT SEA	Krishnendu Sengupta

FIGURE 33: LIST OF ABANDON DRILLS
(Source: Submitted by operators)

General

Title	CARGO HOLD FIRE DRILL ON 17 JUNE 2023				
Description	Emergency Procedure Checklist 9 - Cargo Hold Fire				
Revision No.	1.08	**Status**	Closed	**Recipient**	Krishnendu Sengupta
Date	17-Jun-2023	**Time**	16:30		
Place	AT SEA			**Next Date**	15-Sep-2023
Site	vessel	**Confidential**	♦	**Vessel Name**	FREMANTLE HIGHWAY

Note to Participants

1. Refer to Checklist items in the Checklist section during the drill
2. Verify compliance with checklist items by tick marking the done column for each checklist items.
3. Enter relevant comments in the comments section for each Checklist items.
4. Upon completion of debriefing, completed the below drill evaluation form
5. Attach any additional information / documents applicable to the drill in the documents section

Note: Please do not attach checklist or drill evaluation form in the documents section.

EMERGENCY DRILL EVALUATION FORM

This needs to be filled for all emergency drills.	
Name of Vessel:	M.V.FREMANTLE HIGHWAY
Date/Time of Exercise:	17 JUNE 2023/ 1630 LT
Nature of Exercise:	CARGO HOLD FIRE DRILL
Evaluating Person/Body:	CHIEF OFFICER
Mustering/Deployment time, for Squads:	
a. Emergency Squad:	1633 LT
b. Support Squad:	1633 LT
c. First Aid Squad:	1633 LT
d. Roving Commission:	1633 LT
e. Bridge Backup, including Helmsman:	1633 LT
f. Additional Squads/Staff:	N/A

FIGURE 34: SMS FORM "EMERGENCY DRILL EVALUATION FORM"
(Source: Submitted by operators)

Chapter 6. ANALYSIS / CAUSAL FACTOR

6.1 Fire on EV

Regarding its location, it was confirmed by the duty AB that the fire was initially located **at 8DK hold 4, starboard side, Fr 50-55,** after receiving a fire alarm from a smoke detector in the fire panel, which printout was eventually recovered. **Regarding the fire itself,** it was **firstly observed by the duty AB and subsequently by the 3rd Officer coming from an EV** which stowage position coincides with the first activated fire detector location. The evidence indicates the fire source of ignition was an EV within the block of 24 EVs located at stbd side, aft, deck 8 and likely close to the first activated smoke alarm.

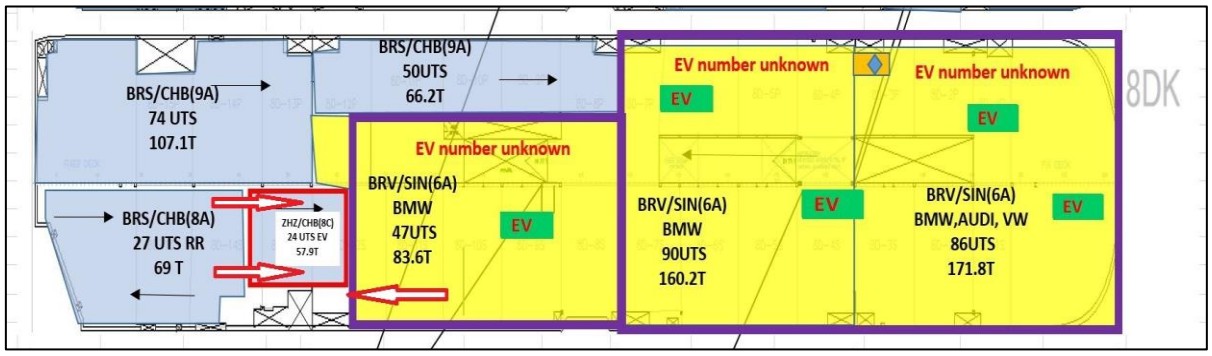

FIGURE 35: LOCATION OF THE EV CARS IN THE AREA IDENTIFIED AS FIRE POINT OF ORIGIN

(Source: DSB)

Unlike internal combustion engine ("ICE") vehicles, electric vehicles (EVs) run on high-voltage lithium-ion batteries that contain flammable electrolytes. This makes fighting flames caused by electric vehicles difficult. An electric car's high battery voltage can result in a condition called thermal runaway. Thermal runaway, which occurs when a battery produces more heat internally than it can release into the environment, is the most frequent cause of catastrophic electric vehicle fires. In the absence of intervention (like cooling), this feedback loop keeps producing increasing heat rises, which could lead to a fire spreading or

explosion. The temperature within the battery will keep rising, which will also raise the battery's current. By enabling the battery to vent rather than explode, modern Li-Ion battery design lessens the likelihood of this happening.

EV flames are far more destructive and challenging to contain than ICE vehicle fires, even though the likelihood of an EV fire is far lower than that of an ICE vehicle (ICE vehicle fires are 60 times more likely to occur). When they fully charge, EVs catch fire more quickly than ICE cars. Flames typically shoot upward and outward simultaneously. Elevations in electric vehicle (EV) flames can reach temperatures beyond 1600 degrees Celsius, a temperature hot enough to burn metals like aluminum, which are commonly used in EV design to reduce weight.

The below figure compares the duration and degrees of EV fires vs ICE cars

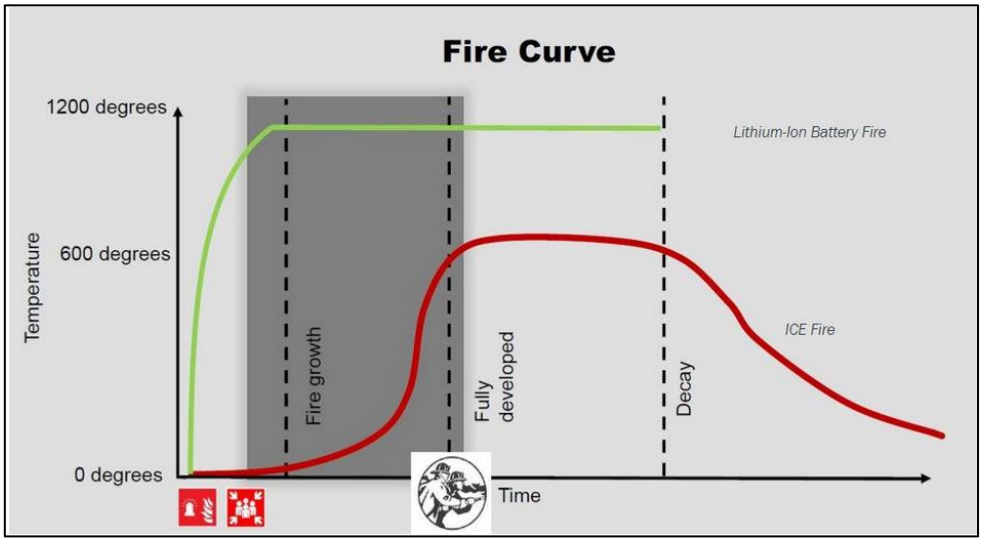

FIGURE 36: EV VS ICS FIRE CURVE
(Source: AMSA)

From the above, it can be understood that EV-related fires are much more complicated to handle. In particular, firefighters involved with EV fires are at great risk from the large volumes of heat, hazardous gases, and chemical fumes produced by this thermal runaway.

Thus, they must be **educated/trained** to use specific equipment and tactics to tackle electric vehicle fires properly. Fighting fires is made more challenging by the complex electrical systems of electric cars and their proximity to water sources, which can potentially pose a risk of electrocution.

6.2 Causal Factor

This section investigates the failure using the information left behind from the initial flaw. The analyst can determine the root cause, contributing factors, direct cause and defenses by analyzing the evidence gathered after the Marine Casualty and the information provided by crew members associated with the vessel fire.

This analysis section presents a methodology for investigating, classifying, and removing the underlying causes of Marine Casualties. This approach considers the people, the resources, and the monitoring involved, as well as the implications for safety, quality, and dependability.

The terms below are used for the Causal Factor Analysis methodology

1. **Direct Cause(s):** Are the events that happened immediately before the accident occurred.
2. **Contributing Factors:** Are the conditions or events that create the opportunity for the immediate cause to occur.
3. **Root Cause(s):** Can be defined as a factor that initiates a sequence of events leading to an accident
4. **Defenses:** Methodology to prevent an action from taking place, or protect the system and the people in it from the consequences

The fire/abandonment and the death of one crew member on Fremantle Highway were the result of multifactorial contributing factors & direct causes, according to the attending Flag casualty investigator.

The main parameters are listed as follows:

1. CARGO EV FIRE AND FAST FIRE SPREADING (DIRECT CAUSE)

In the cargo loading/stowage plan that operators submitted, it was observed that it needs to be more detailed on the location, number, and type of electric vehicles (EVs). In particular, electric vehicles were mixed with ICE vehicles without any further safety precautions being taken. The C/O was familiar with the precise quantity of EVs and their location, and had communicated this. The EV fire was signaled as the cause of the fire from the first instance. The rapid development of the fire and the very quick development of thick toxic smoke made fire fighting using portable fire-extinguishing equipment e.g. using fire hoses etc., very difficult for crew. This excessive smoke made assessing and coordinating the firefighting operation and the vessel abandonment a difficult task.

2. INADEQUATE/INSUFFICIENT TRAINING (CONTRIBUTING FACTOR)

Despite of the fact that most of the ship personnel (except for the Master and Deck Cadet) participated in training programs (REL-PCCEV-Electric Vehicles-Guidance of Safe Carriage and Firefighting On Board & 0455-RORO-Electric Vehicles Fire) which were in place for those crew members involved in the carriage of EVs, that the crew members' reaction time in response to the fire alarm was satisfactory, and that they were adhering to the statutory SOLAS training requirements regarding the vessel FFE equipment; the Chief Officer stated in his interview for the investigation that the EV training he had received and the techniques taught were not practical for the fire situation that took place on board. The statement of the C/O shows that current training did not prepare the crew for the incident at hand. The wording 'inadequate / insufficient training' therefore refers to the training provided, not to the crew members adhering to the training provided. Highlighting the need for the industry and experts to undertake more research into EV fires, FFE focused on Fixed Systems and to consider the improvement of future trainings considering recent events.

In addition, it was observed that the crew members had not been given any specific instruction on the hazards that are associated with jumping from a height of twenty to thirty

metres. On this issue there are no (IMO) instructions in existence. It is possible to argue that seafarers are not normally expected to jump into the sea from such a height. However, taking into consideration the design and structure of a car carrier, which has an accommodation deck on top and limited access to lower decks, especially in the event of a fire, it is essential for crew members to be informed and familiar with the relative dangers that they face. According to the information that was provided, all of them landed in a vertical position on the sea/water, and some of them had backbags. Since instructions and guidelines were not provided prior to the jumping, it appears that they were behaving more in a panic status than in a trained/controlled status.

3. INADEQUATE, SPECIFICATIONS AND/OR DESIGN CRITERIA (CONTRIBUTING FACTOR)

It has been proven that the vessel's fixed fire extinguishing system (Foam) has been successfully deployed; however, it did not positively affect fire extinguishing. The vessel was not provided with additional fire extinguishing or monitoring systems, CCTV, thermal cameras, special vehicle fire blankets, etc. In the event of a fire involving an EV, the only way to cool the battery is to use large amounts of water. Typically, fighting an ICE fire would require 4000 litres of water, while it is estimated that an EV fire would take a minimum of 10,000 litres. The vessel did not have the capacity for this huge amount of water, and obviously, the quantity of water would affect the vessel's stability.

As previously mentioned, the dense smoke rising from the vessel's cargo deck vents caused a number of issues that could not be mitigated due to the absence of a remote control for closing the deck cargo vents. The cargo decks in the car carriers are expanding from fore to Aft, and therefore, if fire is spread is not possible to descend from the upper decks to the lower decks to utilise the LR (Liferafts) or LB (Lifeboats) due to the presence of smoke, flames, and extremely high temperatures (especially if the fire involves EV).

Investigation findings indicated that the fire was initially located at the 8DK, hold 4, frames 50-55; as confirmed by the witnesses (AB and 3/O), the readings of the alarm panel, and the fire alarm printout eventually recovered by the police and shared with the DSB/PMA

upon recovery. Regarding the fire itself, it was firstly observed by the duty AB and then by the 3/O, coming from an EV which stowage position coincides with the first activated fire detector location. The evidence indicates the fire source of ignition was an EV within the block of 24 EVs starboard aft deck 8 and likely close to the first activated smoke alarm.

4. INADEQUATE COMMUNICATION (CONTRIBUTING FACTOR)

During the course of the investigation, one of the problematic areas that was discovered was the communication with the rescue facilities NLCG and RCC as well as with the shore-based management company. According to the statements made by the crew members, the individuals who were in charge of communication were as follows:

- The deep-sea pilot was accountable for communicating with the NLCG/RCC
- The superintendent captain was accountable for communicating with the shore-based management company / DPA

To begin with, it is important to emphasise that the aforementioned individuals do not qualify as crewmembers; they do not belong to the vessel contingency team. Consequently, their appointment to responsibilities during the fire o/b was inappropriate. Furthermore, an examination of the provided data and the investigation's findings indicate that the vessel did not immediately report the fire. . The Deepsea Pilot contacted the Coast Guard at 23:42 LT and notified them at 23:43 LT of the EV car battery fire, stating that it was an EV battery fire on one of the cargo decks of a fully loaded car carrier.

Predicting whether the superintent captain's actions and involvement in managing communication with the shore-based management company/DPA contributed to crew members' improved performance is challenging. However, it should be noted that he was not a member of the emergency team and did not participate in any drills aboard the subject vessel (he was o/b for a few hours). As a result, his understanding of the crewmembers, vessel structure, and FFE was somewhat restricted.

Furthermore, the fact that the superintent captain communicated with the DPA rather than the Master could potentially adversely affect the crewmembers' morale. In a way, this action presented the superintent Captain as superior to the Master, especially considering that it was his initial appointment as Master. Master leadership could be affected.

5. EXPOSURE TO HEALTH HAZARDS OR ENVIRONMENTAL EXTREMES (CONTRIBUTING FACTOR)

Crewmembers were exposed to hazardous environmental conditions of thick toxic smoke, high-temperature heat and flames. At the same time, the feeling of "NO WAY OUT" started to grow between them, since it was clear to them that they could not extinguish the fire and that they did not have the means to evacuate the vessel. Moreover, as per Master, it was not clear how long it would take for the helicopters to arrive at the rescue scene.

Fearful of smoke/fire and heat and unsure of when the helicopters would reach the rescue area, they were compelled to evacuate the vessel immediately out of concern that they would burn to death if they remained o/b. Most of the crew members already had problems with breathing and vision, and they were vomiting. They decided to jump into the water from the bridge because they were desperate. Based on the crewmember interviews, it was determined that there was an absence of a regulated and adequately guided protocol for crewmembers to dive into the sea/water. Instead, it appears that the Master informed them of the presence of rescue vessels and gave his approval for those who desired to jump to do so. Eventually, the rescue boat commanders certainly issued instructions to cease jumping, on about **03:16hrs LT**.

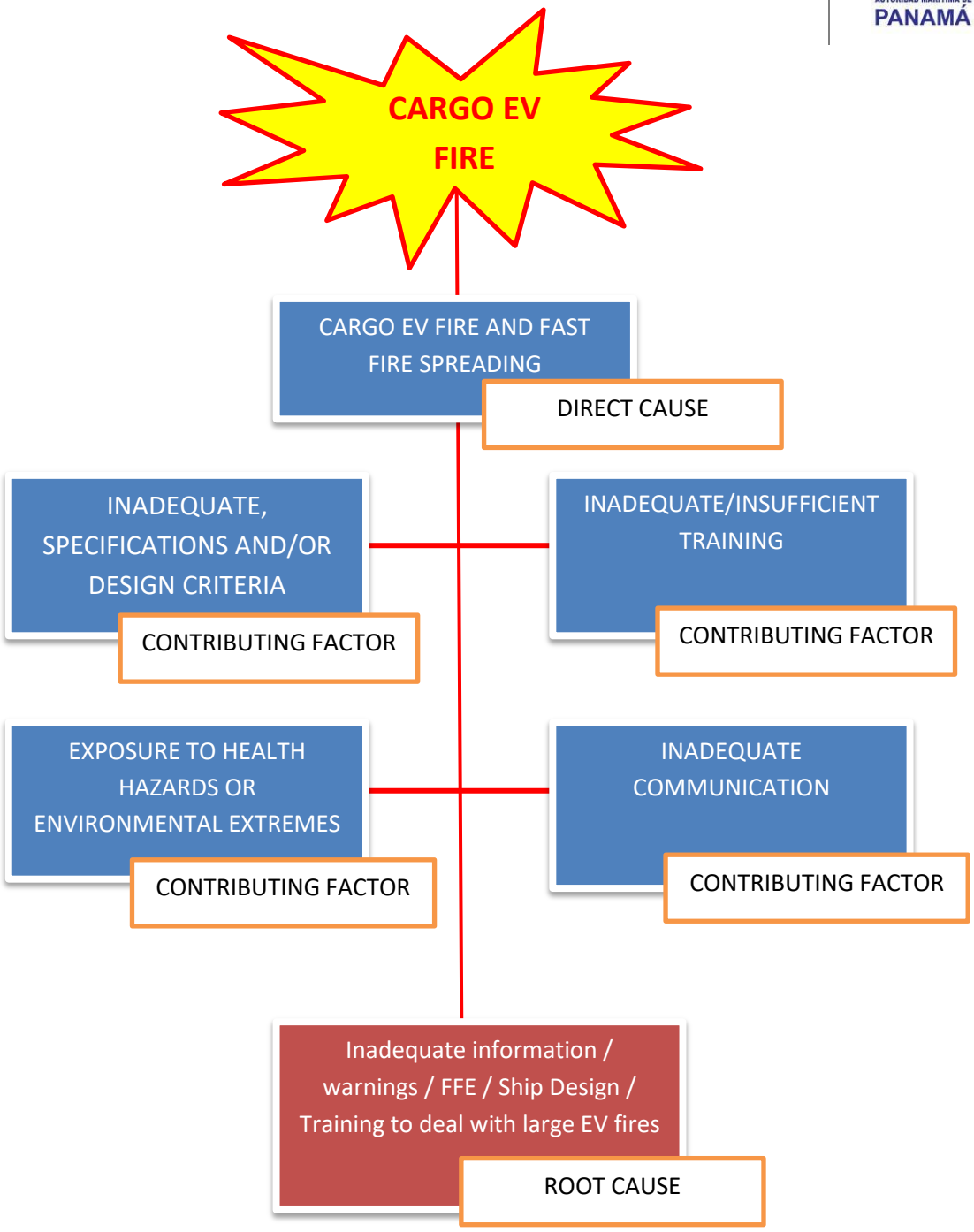

FIGURE 37: CAUSAL FACTOR DIAGRAM

Chapter 7. CONCLUSIONS

After analyzing the identified main causes and contributing factors that led to this fire accident/incident on board, the following conclusions were obtained:

- If the EV vessels were isolated in a restricted area known by the crewmembers and installed with adequate FFE systems applicable to EV cars, the consequences of the fire could be minimized.
- If the Master and crewmembers were aware of the consequences of an EV fire, then they should know that they had approximately 10-15 minutes to control the fire. After that period, the fire could not be controlled, so they should have abandoned the vessel earlier using vessel LB/LR.
- If the vessel had installed a CCTV system or thermal cameras, the source and location of the fire would have been identified earlier, and the vessel fire teams might have had a higher chance of controlling the fire at the initial stages.
- If there was a more prompt, effective and efficient communication between the vessel and NLCG/RCC, valuable time could be saved, the vessel evacuation by helicopters could be conducted earlier in a more controllable manner, and the loss of one seafarer could be avoided.
- If efficient training on how to jump into sea/water from a significant height was conducted, then the crewmembers jumped into the sea would have properly positioning their bodies.

Another topic under consideration is the opening of the cargo vents during the foam system operation. According to crewmembers' statements, the major hazard o/b during the fire was the smoke from the cargo vents. The heavy dark smoke was the main aspect that caused crew members to have difficulties with vision and breathing, and they could not approach the LB and LR. It could be sound to consider that if the cargo vents were closed after the foam was in, the amount of smoke would be less, and consequently, the

crew members might have sufficient time to use the vessel LB/LR. However, it should be noted that closing the cargo vents after the fire expanded was almost impossible since they needed to be closed manually/locally (butterfly dumper); no remote closure was available.

In addition, based on the analysis, the following should be considered for effective, safe EV transportation.

- Bridge and fire teams should always be aware of the exact location, type and number of EV.
- Initial reporting of an emergency situation o/b should always be as detailed as possible.
- Effective communication link should be implemented between Bridge Team members, and shore-based company. Instead, the superintendent captain did communication from the vessel side, who should be considered a passenger and not a crew member.

A lesson learned from this casualty is that when there is a fire with electric vehicles, it is almost certain that a significantly extended fire will be developed that cannot be extinguished by using vessel FFE. Therefore, the Master, within a very short time (10-15 min), should assess the o/b condition and arrange the evacuation of the vessel.

Chapter 8. RECOMMENDATIONS

There will always be a chance of "fire" on vehicle carrier vessels. For this reason, suitable preventive measures need to be put in place to reduce risks and their associated repercussions. Furthermore, as is evident, a variety of preventative measures are advised since the effects of fire on vessels (vehicle carriers as well as Ro/RO passengers) carrying EV and ICE cars might be disastrous.

AA. (Operators - SMS procedures) Crew Training:

Crewmembers tasked with responding to car fires must be made aware of the danger that high-voltage electric components in electric cars represent. The characteristics of an EV fire are different from those of an ICS fire. It is imperative that crewmembers, especially those designated for safety patrols, undergo comprehensive training on the early detection of smoke or heat emanating from within vehicles, specifically focusing on areas prone to battery accumulation, such as the bottom part. Additionally, they must keep an ear out for any "popping sounds," which might signal the start of a thermal runaway event.

Thermal imaging cameras are a valuable tool for crew members during vehicle deck inspections. They should be trained to use these cameras, which can be used to inspect the floor pans of electric cars for signs of overheating. If there are concerns about a specific vehicle, the fire patrol should conduct thermal imaging investigations. Regular use of these cameras and the recording of results can provide early warning of overheated automobiles. The minimum temperature at which thermal runaway may initiate in a battery is estimated to be between 60 and 70 degrees Celsius according some batteries´ manufacturers.

Along with the aforementioned training, crew members should also be conversant with the non-marine phrase "thermal runaway" and trained to recognise the condition's early warning signals. If at all possible, they should also be outfitted with thermal portable detectors.

Since early discovery can significantly help minimize the development of a fire, the

effectiveness of the crewmembers' training should be evaluated or validated by frequently performing fire exercises with particular scenarios on identification and initial reaction to EV battery fires.

BB. (Operators - SMS procedures) Proper Stowage Positioning:

Before the vessel departs, it is critical that an appropriate stowage plan be provided on board. The stowage plan should clearly indicate the exact position as well as the number and type of EV loaded on the vessel. All crewmembers involved with the safety inspections/patrols, as well as deck/engine officers, should attend a "toolbox" meeting to effectively and efficiently familiarize themselves with the positioning and number of EV.

Additionally, EVs have to be well-identified and ideally situated in a location that the crewmembers are aware of. In order to allow crew members using breathing apparatuses to access via numerous access pathways, the area should, if feasible, be on weather decks, away from hazardous materials, have proper drainage, and be well free of any emergency muster points. It is recommended that the electric vehicles (EVs) be segregated from the internal combustion engine (ICE) vehicles in a designated area familiar to the crew. In this area, additional safety measures such as fire extinguishers, structural protection, and monitoring systems should be implemented.

It is also of utmost importance to ensure that dedicated crew members supervise the loading and positioning of EV. This is to prevent any damage to the EV batteries, as EVs often have smaller ground clearance. It is quite possible for the bottom part of the EV, including the batteries, to be damaged by the vessel ramps during loading. The first indication of a damaged battery is fluid leakage. Therefore, the EVs' designated area should be inspected for any evidence of fluid leakage. Additional investigations should be initiated if any are detected.

CC. (IMO) Development of IMO Code for EV carriers

The demand for EVs is continuously increasing. Consequently, the demand for EV transport is increasing. EVs are increasingly being transported by passenger Ro/Ro vessels in addition to car carriers; while the risk of EV fire is minimal, the repercussions are catastrophic. Regarding the transportation of EVs, industry regulations are still in the stage of recommendations and guidance. At present, vessels are not obligated to adhere to any worldwide mandatory regulatory standards. Conversely, the emergency (EV fire) and safety transportation protocols that are operationally implemented are formulated independently by each operator/charterer, relying on their expertise and industry guideline recommendations, without undergoing any form of audit or certification.

Moreover, it should be noted that vessels built prior to the demand for EV transportation were outfitted with FFE suitable for loading and transporting ICE vehicles. However, it is now apparent that these vessels also transport EV without any upgrades to their cargo deck areas and FFE.

Regulations pertaining to construction, LSA/FFE, and inspections of vessels involved in the transportation of electric vehicles should be updated to reflect the modifications made to the hazard parameters, duration/temperature degree of fire, and means of extinguishment, among others.

Evidently, the industry "needs" the development of standardized protocols to ensure the safe transportation of electric vehicles; thus, the International Maritime Organization (IMO) should contemplate the creation of an IMO code for EV carriers.

DD. (shipbuilders/shipyards/classification societies) Design/Construction Limitations:

During the casualty investigation, several design/construction limitations of large vehicle carriers were identified. Due to the complexity of construction and sophisticated operation of this type of vessel, the identified limitations should be addressed to the shipping industry

(shipbuilders/shipyards/classification societies) so that corrective actions/improvements can be implemented.

1. **Stability:** One of the most pressing issues with large vehicle carrier design is the inclusion of cargo on upper decks and accommodation at even higher levels. This design flaw means that even a minor shift of cargo can escalate into a major threat to the vessel's stability. The situation is further complicated by the fact that EVs are generally heavier than ICS cars and are often loaded on the top cargo decks for better access and monitoring. In the event of hull failure or a fire, the extensive quantity of water required for EVs can lead to rapid flooding and the potential capsize of the vessel. Therefore, consideration should be made to develop/install the appropriate means for improving the stability of this type of vessel in emergency cases by minimising the amount of accumulated water in the cargo areas.
2. **The lack of transverse bulkheads** in the internal structure of vehicle carriers is a significant issue. This design flaw compromises the watertight integrity of the ship during water ingress or flooding. Additionally, the absence of bulkheads allows fires to spread more rapidly, as there are no internal divisions to contain the flames. Therefore, consideration should be made to design/develop the appropriate means (even portable) to restrain the rapid spread of fire and flooding (in emergency cases) within the cargo areas.
3. **Location of Lifesaving Appliance**: Lifeboats and life rafts are used to evacuate the ship as quickly as possible when it is time to abandon it. The location of lifeboats and liferafts on vehicle carriers is usually very high, which makes it even more difficult to lower them at sea, especially when the ship is listing or on fire. Furthermore, the crew quarters are located on the uppermost deck; in the event of a fire below decks, it is not feasible to descend from the upper decks to the lower decks to utilise the LR or LB due to the presence of smoke, flames, and extremely high temperatures (especially if the fire involves EV). Therefore, consideration should be made to develop/install protected areas (from smoke/heat) for the LB/LR.

4. **Hight of open decks:** As previously stated, in the event of a fire, access to the lower decks is restricted, and there are no viable alternatives for abandoning the vessel from the lower deck. Consequently, the only viable courses of action are helicopter rescue, if feasible, or jumping into the water from the open decks. However, jumping into the sea/water from a height of 20–30 meters is not considered a safe manner of abandoning a vessel. Therefore, consideration should be made to develop/install means of crew-safe evacuation from the highest open decks.
5. **Remote operation/closure of vents in cargo deck:** When the foam system is activated, the cargo deck vents should be opened. But, the open vents will let a lot of smoke to escape, especially in the event of an EV fire. This makes it harder to put out the fire and makes it more difficult to approach or operate the LB/LR (reducing crew members' visibility). Since the vents cannot be closed locally due to the heat and flames, the vessel should be provided with the alternative of remote operation (emergency closure).

EE. Additional measures to restrict EV fires

The vessel operator's role is vital to guaranteeing the safe transportation of electric vehicles. Consequently, they should think about updating their SMS and adding these extra tools/measures for EV-related fire, making them obligatory rather than optional.

These measures consist of:

1. Automobile fire blankets or other specialized textile barriers can be effective in certain situations. However, it's important to understand the unique hazards that may arise from EV fires. These fires can escalate rapidly, producing fumes and smoke that impair sight and cause intense heat. This is particularly challenging when dealing with restricted access around cars on a ro-ro deck. When a vehicle is at a greater risk of fire, such as when battery coolant is leaking, these fire blankets

can be a preventive measure. They will contain the flames, but the thermal runaway event will still occur.

2. Full-face respirators) to protect them from the poisonous fumes released by electric vehicle fires while doing emergency tasks like getting lifeboats ready for launch.
3. Specialized firefighting equipment to keep crewmembers/fire team safe while putting out EV fires, like

    a. Gloves rated for high-voltage use
    b. A gas detector to analyze the atmosphere for explosive gases.

4. Early fire detection can be achieved by installing closed-circuit television (CCTV) systems with flame identification and heat detection qualities in areas where vehicles, including EVs, are present. Thermal runaway is usually detectable between 60 and 70 degrees Celsius. It is important to take CCTV systems' placement into account. These are usually positioned on a vehicle deck fore and aft. To facilitate prompt identification of thermal runaways, operators must think about installing more CCTV cameras with thermal detection capabilities in the aft ship directions. This makes it possible to pinpoint the exact location of the fire as well.