HELLENIC REPUBLIC
HELLENIC BUREAU FOR MARINE CASUALTIES' INVESTIGATION

HBMCI
Hellenic Bureau for Marine Casualties Investigation

MARINE CASUALTY SAFETY INVESTIGATION REPORT 10/2014

FIRE ON BOARD RO-PAX IERAPETRA L (29-11-2014)

November 2019

Contents

Foreword

The Hellenic Bureau for Marine Casualties' Investigations (HBMCI) was established by Law 4033/2011 (Government Gazette 264/12.22.2011), in the context of implementing EU Directive 2009/18/EC. HBMCI conducts technical investigations into marine casualties or marine incidents with the sole objective to identify and to ascertain through respective analysis, the circumstances and contributing factors that led to them and to draw useful conclusions and lessons learned that may lead, if necessary, to safety recommendations addressed to parties involved or stakeholders interested in the marine casualty, aiming to prevent similar future marine accidents.

The conduct of Safety Investigations into marine casualties or incidents is independent from criminal, discipline, administrative or civil proceedings whose purpose is to apportion blame or determine liability. This investigation report has been produced without taking under consideration any administrative, disciplinary, judicial (civil or criminal) proceedings and with no litigation in mind. It does not constitute legal advice in any way and should not be construed as such. It seeks to understand the sequence of events which occurred on the 29th of November 2014 and resulted in the examined serious marine casualty. Fragmentary or partial use of the contents of this report, for other purposes than those it is produced for may lead to misleading conclusions. The investigation report has been prepared in accordance with the format of Annex I of respective Law (Directive 2009/18/EC) and all times quoted are vessel's time unless otherwise stated as Local Time (UTC +2).

Under the above framework HBMCI has been examining the fire on board Ro-Pax IERAPETRA L, which occurred on the 29th of November 2014, in the Adriatic Sea, approximately 27nm SE of Brindizi. This report is mainly based on information from the vessel's VDR and evidence that have been derived from the interviewing process and during HBMCI's visit on board.

Glossary of possible Abbreviations and Acronyms		
1	A/B	Able seaman
2	AIS	Automatic identification system
3	Bf	Force of wind in Beaufort scale
4	CoC	Certificate of Competency
5	D/G	Diesel Generator
6	DOC	Document of Compliance
7	GMDSS	Global maritime distress and safety system
8	GPS	Global positioning system
9	gt	gross tonnage
10	HCG	Hellenic Coast Guard
11	IMO	International Maritime Organization
12	ISM	International Management Code for the safe operation of ships and for pollution prevention
13	knots	unit of speed equal to one nautical mile (1.852 km) per hour
14	KW	Kilowatt
15	LT	local time
16	nm	nautical miles
17	2/O	2nd Officer
18	C/O	Chief Officer
19	O(s)OW	Officer(s) on the watch
20	O/S	Ordinary Seaman
21	PPE	Personal protection equipment
22	SMC	Safety management certificate
23	SMS	Safety management system
24	SOLAS	Convention for the Safety of Life at Sea 1974, as amended
25	STCW	International Convention on Standards of Training, Certification and Watchkeeping for seafarers
26	UTC	Universal co-ordinated time
27	VDR	Voyage Data Recorder
28	VHF	Very high frequency (radio)

1. Executive Summary

On 29 November 2014 at approximately 18:00, Ro-Pax "IERAPETRA L" sailed from Brindisi port with a crew of 23. The vessel departed without passengers and cargo on board, after she had completed her round voyages between the port of Brindizi (Italia) and Durres (Albania), for a single voyage to Igoumenitsa, where she was scheduled to undergo her annual maintenance.

At approximately 21:01, while the vessel was en route 27nm South East of Brindisi, , a fire was detected in the port exhaust funnel. The fire was spotted by the officer on the watch in the bridge and it was described as a full flame torch coming out of the funnel with the fire flame extended to the adjacent lounge area inside the ship. At the same time the fire detection system was activated, indicating fire at the accommodation area, followed by the activation of the sprinkler system. The OOW immediately alerted the crew through the public address system and master was called upon the bridge.

The crew took immediate action by stopping both main engines and ventilation fans, air conditioning units, as well as auxiliary diesel generator engines No 2 and 3 because they were located at the port side area of the engine room where the fire broke out. They also closed fire dampers, side scuttles, fire doors and cut the power supply to the electrical circuits of the affected area.

While dealing with a leak in the discharge pipe of the main fire pump, the designated crew members were summoned and started fighting the fire and cooling adjacent places, using all available means, while the starboard side life-saving equipment was prepared for launching, if needed.

The Master reported the situation to the Italian authorities as well as to Piraeus Joint Search and Rescue Coordination Center and the vessel's managing company. The Bari Coastguard Authority took over the coordination of the incident establishing contact with the vessel for any assistance that may be needed and deploying available means.

At approximately 22:15 the fire was under control and a few minutes later it was reported that it was fully extinguished. IERAPETRA Lreturned back to the port of Brindisi, by her own means using the starboard main engine which was not affected by the fire. She arrived at Brindisi at approximately 05:30 in the morning of the following day where she was inspected by the Italian Authorities and her Class.

The fire caused extended damages to the inner side of the port side funnel and also to the adjacent to the port side funnels accommodation areas on decks No 7 and 8. No pollution and no injuries were reported.

Investigation identified that the main reasons contributing to the fire were related to the visual check and inspection, to make sure that all valves of the port main engine fuel oil return system were set and operated correctly, prior to the vessel's departure for Igoumenitsa, following the maintenance carried out. In particular the most possible cause for the fire breakout is the valve of the port side "return chamber", which was a small tank for the accumulation of fuel returns from the main engine's fuel supply system towards the recirculation to the fuel supply system, which had been damaged and found at closed position and this caused the fuel to overflow the tank and be led

by its air extractor pipe towards the interior of the port funnel duct, where it came in contact with hot surfaces of the main exhaust gas pipe.

Safety recommendations focused on the necessity for visual inspections and crosschecks following works carried out during maintenance (especially for setting the valves of the fuel supply systems), and the establishment of a safety arrangement like a level detector alarm, for dealing with possible overflow of all tanks that contain fuel and have air extractor pipes that end up within the funnel ducts of the vessel.

Note:

- *This report is mainly based on information and evidence that have derived from the interview process and information collected from those individuals involved in the marine casualty, as well as electronic positioning data provided by the competent authorities of the Hellenic Coastguard.*

2. Factual Information

Figure 1: Ro-Pax IERAPETRA L (photo credits: archipelagos.com)

2.1 Ship particulars

Vessel's name:	IERAPETRA L
Type of vessel:	Ro-Pax
Flag:	Greek
Port of registry:	Agios Nikolaos 07
IMO number:	7429669
Call sign:	SZIY
DOC company (operator):	ANEK A.E.
IMO company no.:	0517231
Date keel laid:	1975
Shipyard/Place of built:	Kanda Shipbuilding CO., LTD – KURE – CITY, Hiroshima, Japan
Classification society:	RINA
Length overall:	137.00 (m)
Breadth overall:	22.00 (m)
Gross tonnage (registered):	12891
Net tonnage:	5672
Number/brand of main engines:	2 internal combustion engines / Pielstick
Main Engine max. output:	15511 (KW)
Hull material:	Steel

2.2 Voyage Particulars

Port of departure:	Brindizi (Italy)
Port of destination:	Igoumenitsa (Greece)
Type of voyage:	Short international
Cargo/passengers information:	No cargo / no passengers
Safe Manning:	16 (as of 02-12-2014)
Manning:	23

2.3 Weather data

Wind (direction-force):	NE – 5 Bf
Sea state:	Moderate waves
Visibility:	Good
Light/dark:	Dark
Sky:	Overcast

2.4 Marine Casualty information

Type of marine incident:	Fire
IMO Classification:	Marine casualty
Date, time	29-11-2014, 21.01 LT
Location	Adriatic Sea
Position (approx..)	40^{o} 30 N, 018^{o} 33 E
Ship's voyage segment:	Mid-water, on route
Place on board:	Vessel's funnel duct, part of accommodation
Human factor data:	(See analysis part)
Consequences to individuals:	None
Consequences to environment:	None
Consequences to property:	Damage to ship (port funnel duct, accommodation spaces)

3. Narrative

Ro-Ro Passenger ferry "IERAPETRA L", was engaged in regular commercial Ro-Pax service in the Adriatic Sea between the ports of Bari, Italy and Durres, Albania. On the 30th of September 2013 she had completed her voyage schedule itineraries and remained idle in Bari and later on at Brindisi port, where some maintenance works for preparation of her forthcoming inert period, had been carried out at the engine department.

On 29 November 2014 at approximately 18:00, IERAPETRA L sailed from Brindisi with a crew of 23. The vessel sailed without passengers and cargo on board, for a single voyage from Brindisi to Igoumenitsa, where she was scheduled to undergo her annual maintenance.

At 21:01 while the vessel was en route 27nm South East of Brindisi, a fire was detected in the port exhaust funnel. The fire was spotted by the officer on watch in the bridge and it was described as a full flame torch coming out of the funnel with the fire flame extended to the adjacent lounge area inside the ship.

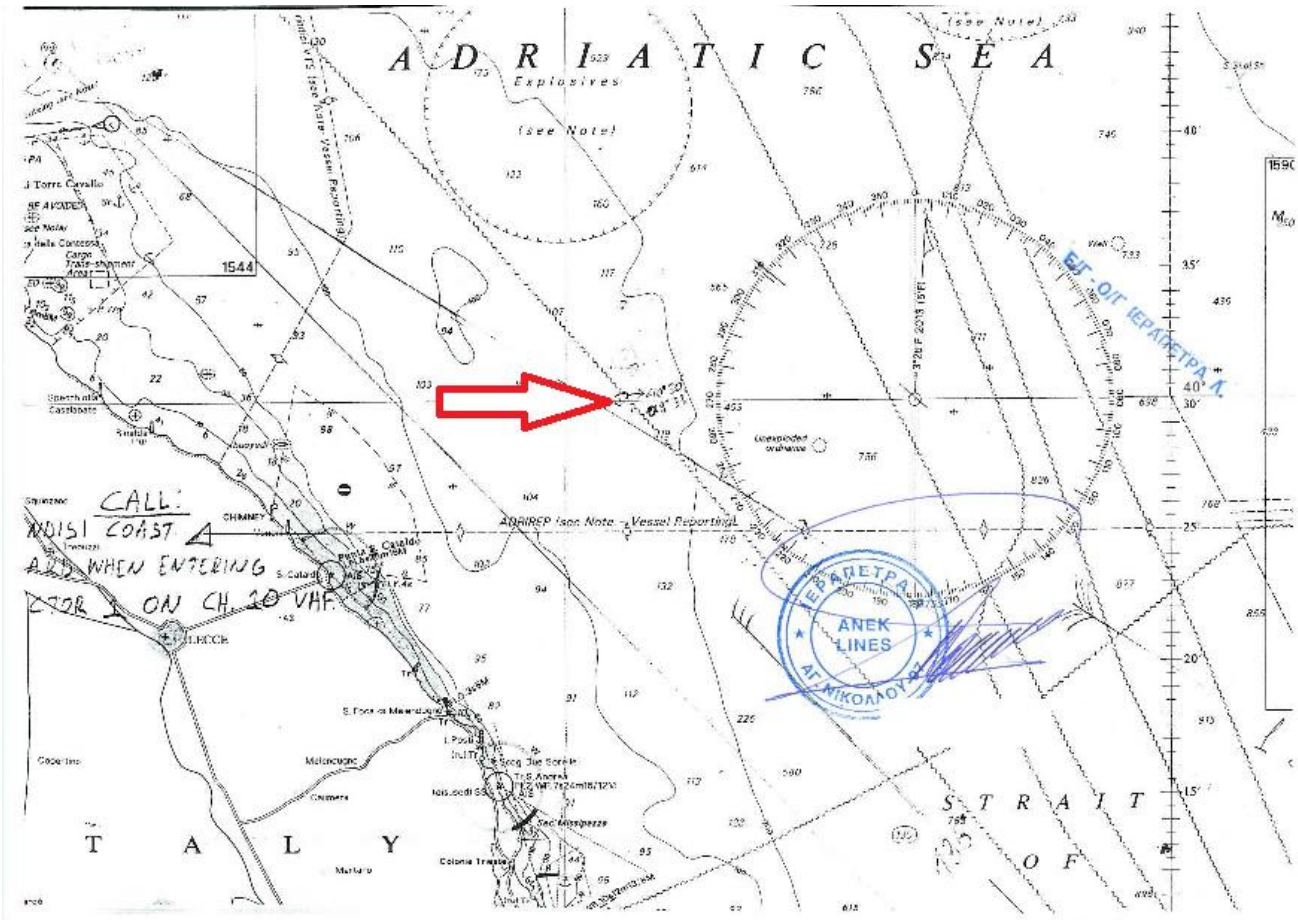

Figure 2: The vessel's position (**40° 30 N, 018° 33 E**), as recorded by Master on the chart, at the time of the fire detected

At the same time the fire detection system was activated, indicating fire at the accommodation area, followed by the activation of the sprinkler system. The OOW immediately alerted the crew by use of the public address system and the master was called on the bridge.

3.1 Emergency Response Actions

In parallel the OOW informed the crew in the engine control room. The Chief Engineer who was still in the control room approached the port side area of the engine room where he saw smoke coming out from the top of the port side funnel trunk. At 21:06 both main engines were stopped as well as auxiliary D/G engines No 2 and 3 because they were fitted at the port side area of the engine room where the fire broke out. The second engineer and a member of the engine crew started the

emergency fire pump and one out of two main fire pumps. By that time they noticed that the discharge pipe of the main fire pump was leaking, spraying the water onto the No1 D/G engine. However engine crew took immediate actions and controlled the leakage with temporary means in order to keep the pressure of the fire line stable and avoid any damage to the D/G.

The crew members summoned the fire extinguishing teams and stop ventilation fans, air conditioning units, fire dampers, side scuttles, fire doors as well as the power supply to the electrical circuits of the affected area.

Meanwhile, the Master reported the situation to the Italian authorities as well as to Piraeus Joint Search and Rescue Coordination Center and the vessel's managing company. The Bari Coastguard Authority took over the coordination of the rescue incident remaining in contact with the vessel for any assistance that may be needed and deploying available means.

M/V "MONTENERO" (IMO nr: 9294123) was instructed by Bari Coast Guard Authority to remain close to IERAPETRA L, in case further assistance, was required.

3.2 Firefighting and extinguishment

Firefighting equipment was deployed and fire teams started fighting the fire, using fire hoses, foam extinguishers, CO2 fire extinguishers, targeting at the top of the chimney and through the air vents of the port side funnel from both sides on decks No 8 and 9. A separate team was spraying water to the funnel casing on deck No. 7 and upper garage of deck No.5 for cooling the adjacent compartments. Moreover the starboard side life-saving equipment was prepared for launching, if needed.

At approximately 22:15 the fire was under control and a few minutes later it was reported that it was fully extinguished. The vessel returned back to the port of Brindisi by her own means using the starboard main engine which was not affected by the fire.

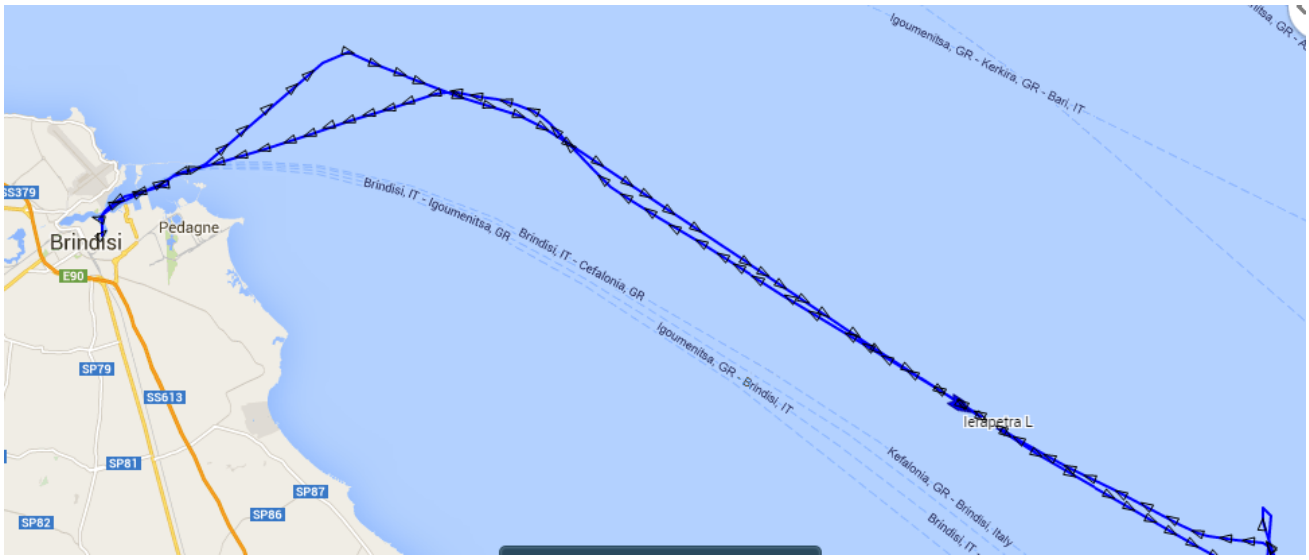

Figure 3: route of IERAPETRA L, from departure from Bridizi until her return to port (source: marinetraffic.com)

At approximately 05:30 of the following day, the vessel arrived at Brindisi where she was inspected by the Italian Authorities and her Class.

3.3 Damage and repairs

The fire caused extended damages to the inner side of the port side funnel and also to the adjacent accommodation areas on decks No 7 and 8. The engine room was also affected by the oil leakage and mostly by the firefighting materials and residues. No pollution and no injuries were reported.

The following figures show the extent of damage.

Figure 4: Capture of the aft side of the port side funnel duct with evident results of the fire

Figure 5: Capture of the fore side of the port funnel duct

Figure 6: Capture from the external accommodation spaces at the port side of the vessel (deck 8)

Figure 7: Capture of the external accommodation spaces at the port side of the vessel (deck 7)

Figure 8: Capture of the port side accommodation lounge (deck 7)

Figure 9: Capture of the inside of the port funnel duct

Figure 10: Capture of the floor of the engine room, right below the port funnel, with evident residues from the extinguishing process

On the 06 December 2014 IERAPETRA L sailed under towage for Piraeus port where she arrived on 10 December 2014 for necessary repairs.

During initial repair actions, it was found out by the company engineers that the valve to the supply pipe of the "Return Chamber", within the fuel oil supply system of the main engines, was damaged and found at a closed position.

The vessel changed ownership in 2016 and thereafter was fully repaired. Since October 2017 she came into operation under the name "AQUA BLUE".

3.2 Investigation actions

The investigation team first came on board the IERAPETRA L on the 15th of December 2014 after the vessel was towed to Keratsini (Piraeus). The investigators spotted that there were droplets of oily substance sprayed all around the area of the funnel, on the external bulkheads of the decks, as well as on the life boats nearby. Relevant samples were taken to be analyzed on the nature of the substance. In the following days data collection included interviewing the key crew members involved in the accident and extraction of the VDR data.

3.3 The key crew members

The main crew members that were identified and thereafter interviewed for the accident are the following:

1. **Master**: the 54 years-old, Greek Master had signed on board the IERAPETRA L for 25 days (from the 4th of November). Having the rank of Master he carried long sea experience as deck officer from 1980, with various types of ships, such as cargo ships, motor yachts, cruise ships and Ro-Pax vessels (from 2002 and on). He had been working for the company from 2010 on similar type of vessels. At the time of the accident he had just finished dinner and was heading to the bridge.

2. **Chief Officer**: the 31 years-old, Greek C/O had 6 years of experience at sea as deck officer, being a C/O for almost a year. He had signed on IERAPETRA L for one and a half months (since the 14th of October). He had served on Ro-Pax vessels also of the same company for some months. The C/O's duties included navigation and the role of safety officer. At the time of the accident he had just finished dinner and was on his way to the bridge.

3. **2nd Officer A**: The 2nd Officer A, was Greek, 48 years-old and almost 20 years as experience at sea as a deck officer, mostly on Ro-Pax vessels. He had worked for the company before for almost 4 years and had also served on board the IERAPETRA L for 18 months, from 2010 to 2012. He joined the vessel the day before departure from Bridizi (28-11-2014). His duties included being navigation officer on the watch 12.00-16.00 and 00.00-04.00. At the time of the accident he happened to be at the bridge, although not on duty.

4. **2nd Officer B**: The 2nd Officer B was Greek, 36 years-old. His experience included 10 years at sea on board tankers, cargo and container vessels as well as ferries. As deck officer, since 2014 he acquired the certification of Master B' rank and during his career had served for almost a year as Master on a small ferry. He began working for the company within 2014 and had joined the IERAPETRA L on the day of the departure. His duties included navigation, GMDSS officer and person in charge of the fire-fighting team. During the time of the accident he was on watch at the bridge, as he held the 08.00-12.00 and 20.00-24.00 watch.

5. **Chief Engineer**: the Chief Engineer was also Greek and his age was 40. His experience at sea included 15 years on Ro-Pax and high speed vessels, while he had been working for the company for almost 5 years. He had joined the IERAPETRA L on the 2nd of October and was present during the maintenance works that had been carried ever since on the vessel. At the time of the accident he was somewhere between the Engine Control Room and the Generator Room.

6. **2nd Engineer**: at the age of 53, the Greek 2nd Engineer held almost 29 years at sea. He had served on board Ro-Pax vessels for over 6 years and he had been working for the company since 2012 as 2nd Engineer. He had served again on the IERAPETRA L, for a 5 month period in 2012, but his current contract had started on the 28th of November, when he joined the ship. At the time of the accident he was resting.

7. **3rd Engineer A**: the 3rd Engineer A was Greek, 54 years-old and had experience at sea since 1998 as cadet. He had become an engine officer in 2001 and had worked mostly on tankers and container vessels from 2001 to 2013. He had joined the vessel from the 5th of July 2014. He held the 20.00-24.00 watch in the engine room at the day of the accident.

8. **3rd Engineer B**: the 3rd Engineer B was Greek, 46 years-old and had experience at sea since 1994. He had become an engine officer in 1989 and had worked mostly on bulk carriers and general cargo ships. He had little experience on Ro-Pax vessels for a few months. He had joined the vessel just before departure, on the 29th of November. He would hold the 00.00-04.00 watch at the engine room. At the time of the accident he was in the officers' mess room having dinner.

9. **Assistant electrician**: the assistant electrician was Greek, 32 years-old and had seagoing experience on board Ro-Pax of the same company for certain periods since 2010. He had joined the vessel since the 25th of May 2014. His duties were during daytime in the engine room.

All the aforementioned crew members held proper certificates for their ranks and duties and had adequate rest periods prior to the accident, as per relevant evidence gathered.

4. Analysis

The analysis of the examined marine casualty aims to identify the factors and causes that contributed to the marine casualty, taking into account the sequence of events and the collection of evidence and information during the investigation process.

4.1 Maintenance on board

IERAPETRA L had ceased her scheduled voyages between the ports of Bari (Italy) and Durres (Albania), since the 30th of September 2014, and had remained in the port of Bari until the 3rd of October waiting for instructions from the Company.

On the 3rd of October the ship moved to the Bridizi port, where maintenance was scheduled to take place, as the vessel was having her annual inert period, which was according to the Company's commercial plans. Maintenance was carried out mostly by the crew, until the 28th of November, when the vessel began preparations for departing to the port of Igoumenitsa (Greece).

According to the records of the vessel's engine log book, maintenance included:

- Painting and cleaning of engine room bulkheads and main engines
- Cleaning the filters of Diesel Generator nr.1 and nr.3
- Adding oil in Diesel Generator nr.2
- Cleaning of the filters of the sewage treatment plant
- De-assembling, repairing and assembling the leakage tank suction valve
- De-assembling and assembling the expansion joints of the port main engine
- Change and cleaning of the oil supply pumps of cylinder nr.2 of Diesel Generators nr.2 and nr.3
- Cleaning the sludge tank L.O. purifier
- Cleaning the air suction of certain cylinders of Diesel Generators nr.2 and nr.3
- De-assembling, repairing and assembling of steam return pipe of boiler
- Replacing the pressure adjuster for the oil supply of the starboard main engine.
- Replacing the pressure adjuster for the seawater cooling system of the port main engine
- Maintenance of the sewage pumps, hot water pumps, cooling pumps of the diesel generators and feed water pump of the boiler nr.2
- De-assembling, replacing the gasket and assembling an expansion joint of the port main engine
- Cleaning the crank case of diesel generator nr.1 and replacement of oil

4.2 Sampling of oily spray and results of chemical analysis

As mentioned in paragraph 3.2, during the visit of the investigators on board the vessel, it was witnessed that the areas around the port side funnel, where the fire initiated, were covered by oily droplets, in a spray form. Additionally visible oil traces, coming from the spaces above i.e funnel duct, were evident on the surface of the port exhaust pipe as well as the port side main engine inside the engine room, as shown in the following figures.

Figure 11: the area around the port funnel. Traces of the oily mixture spray are quite evident on the bulkheads (deck 7, port side)

Figure 12: the same spray appears also on the life boat and its crane, which were nearby the port funnel (deck 8 port side)

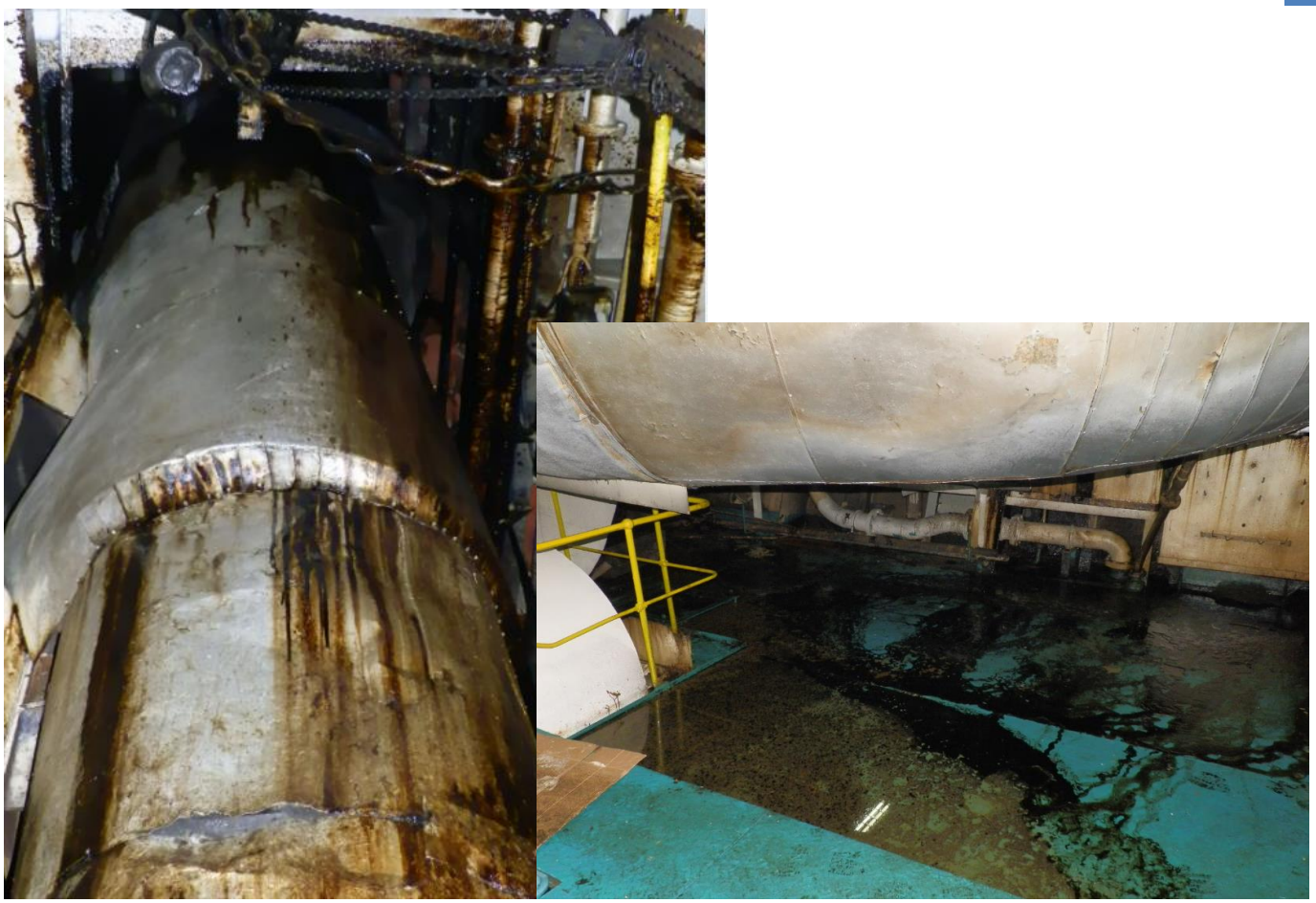

Figure 13: visible oil traces on the surface of the exhaust pipe and the port side main engine room

The investigators took a sample of these oil markings, using wads. The samples were analyzed by the National General Chemical Service and the results, showed that it was Heavy Fuel Oil with water and particles from the wads. The results also noted that this type of oily substance did not contain any used mineral oils (lubricant oils), or other type of oil, such as marine gas oil (used in the vessel's generators).

Therefore, it was verified that around vessel's port side funnel, where the fire was spotted initially by the crew, as well as inside the engine room, these areas were covered by sprays of fuel oil, which was used in vessel's main engines. The findings led the investigation into the direction of examining the vessel's main engine fuel oil supply system.

4.3 Possible cause of the fire

4.3.1 Design and construction factors related with the fire source

The main evidence of the cause of the fire was the existence of fuel oil droplets in the port funnel's duct and inside the engine room, which in turn could only be traced back to the operation of the port main engine fuel oil supply system.

As mentioned, during the evaluation of the cause of the fire in Piraeus, it was found that the valve from the "Return Chamber to the fuel supply pipe", which is fitted within the oil fuel supply system of the main engines, was damaged and closed which in turn have caused the fuel oil to overflow inside the return chamber and thereafter through its air extractor pipe. The air extractor pipe unlike most of the air-vent pipes of the tanks containing fuels which end up on deck 5 (garage deck), was fitted at the upper edge of the duct funnel in a small space that was air vented through a natural ventilation opening. Said space had a remotely operated fire damper for fire protection purposes.

Moreover, in the piping system of the air extractor pipe there was no safety arrangement which would either activate an alarm in case of overflow or ensure that fuel in the case of overflow would not be led towards the funnel through the air extractor pipe, which was a totally free-flow pipe. The return chamber itself had no level indicator, so the level of fuel contained in it could not be monitored.

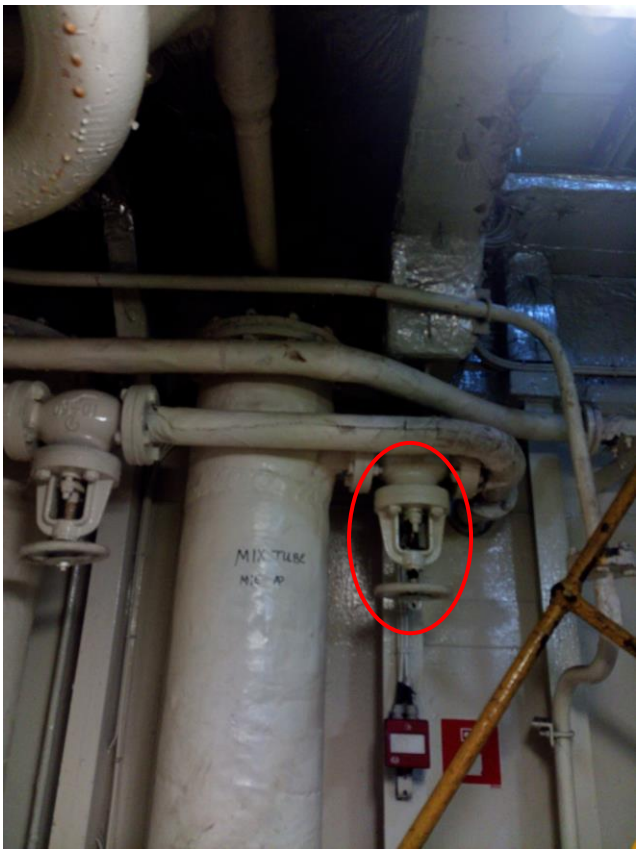

Figure 14: the valve from the Return Chamber to the fuel supply pipe, which was found damaged (photo captured after ship's repairs)

The most possible time for the valve from the return chamber to the supply pipe, to have been damaged was during the maintenance works which were conducted in the engine room in Brindisi. Consequently the valve remained in the closed position, unnoticed by the engine crew until finally it was too late.

Therefore, the whole design and construction of the return chamber included a high risk factor, as in the case of continuous overflow of the tank and with no level indicators or other overflow alarms in place, as happened in the examined case due to a malfunction of the associated equipment, the fuel would end up in the port funnel duct. It appears that the closed valve towards the fuel supply pipe caused such a continuous overflow of the Return Chamber with no particular signs or alerts to the crew on watch at the engine room.

Figure 15: The air extractor pipe within the port funnel duct; capture is from underneath the panel where the air extractor pipe ends up (see indicator arrow and next figure). On the right side of the figure the main exhaust pipe is visible (photo captured after the repairs)

Figure 16: The air extractor pipe's ending (indicated) over the panel within the port funnel duct (photo captured after the repairs)

Considering the fact that the vessel had covered 27 nm in almost 3 hours from departure explains the time elapsed for the Return Chamber to have been overflown by fuel returns, as well as the time for the fuel to have been led – unnoticed by the crew on watch in the engine room – by its extractor pipe to the port funnel duct where eventually it came in contact with hot surfaces.

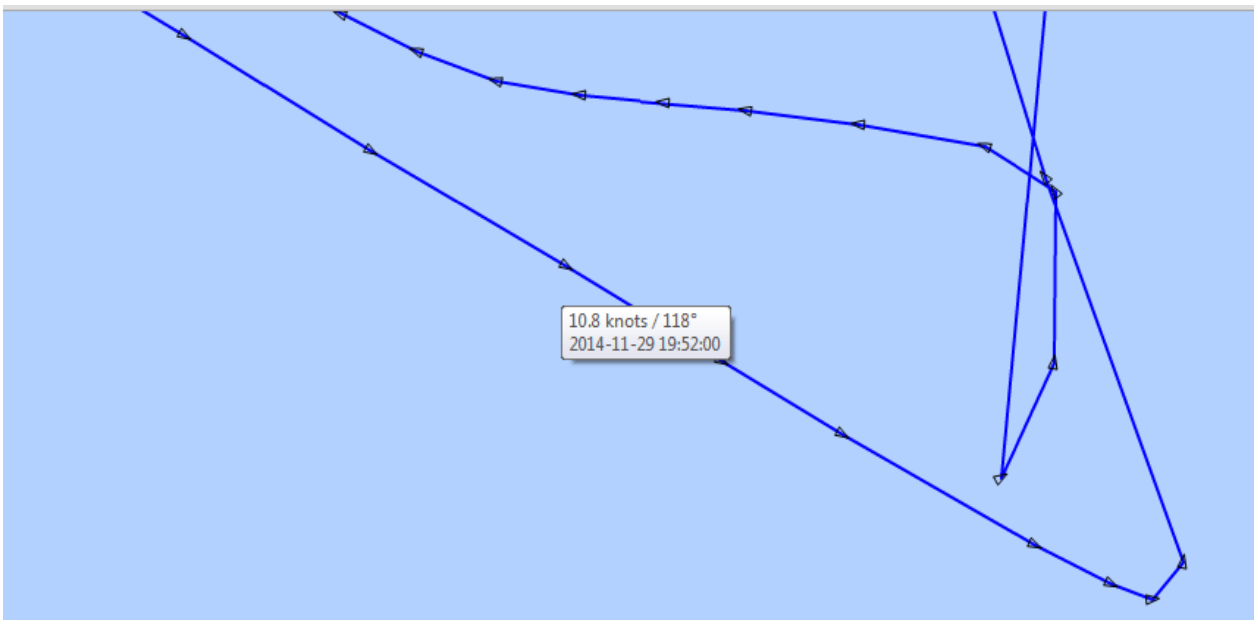

Figure 16: IERAPETRA L was recorded to be sailing at approximately 10.8 knots (reduced engine load) a few minutes before the fire broke out. (source: marinetraffic.com)

From the examination of the vessel's drawings it was found that the relevant drawing concerning the fuel oil piping system for the main engines, showed no indication that the air extractor pipe's ending of the return chamber, was leading up inside the port funnel duct as is evident in the figure below. Additionally the relative drawing of the port side funnel duct showed no indication of the existence of the air ventilation pipe inside that space. Finally the mist box as shown in the figure below was missing in the actual piping arrangement.

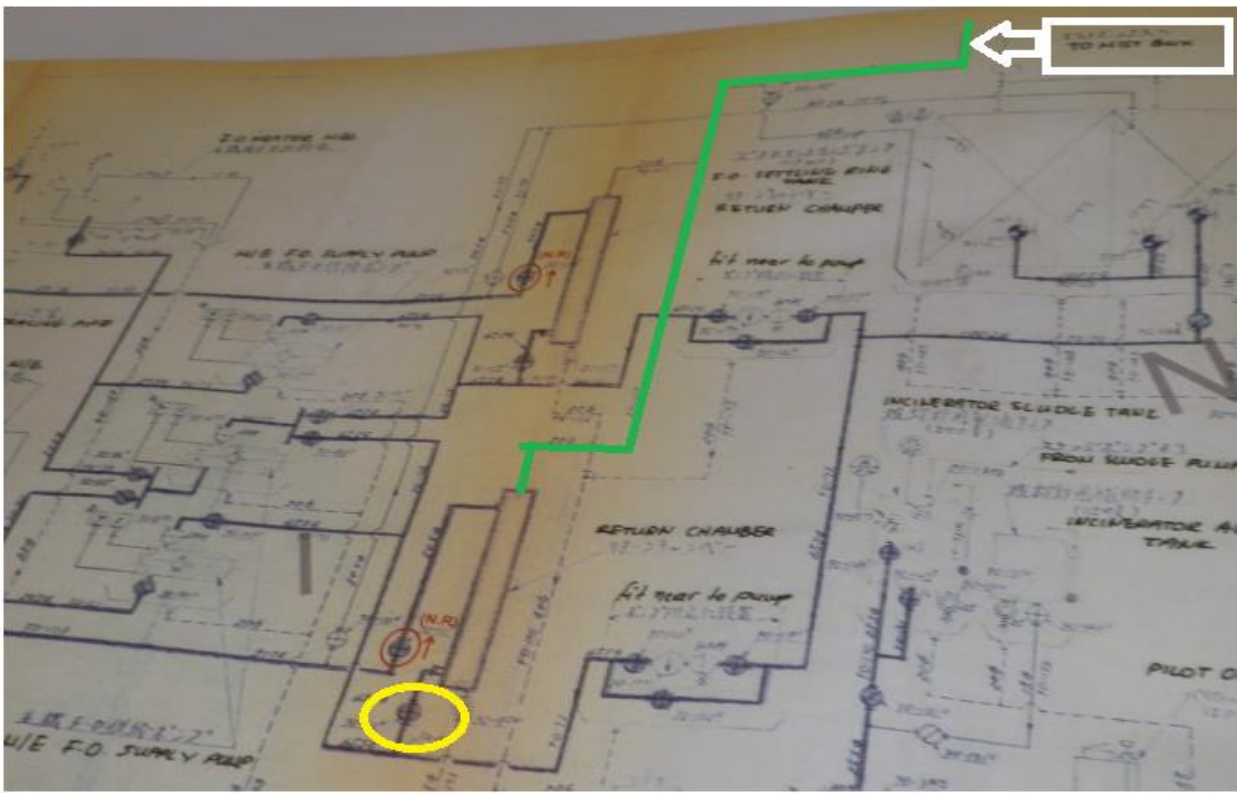

Figure 17: Capture of the fuel oil piping diagram showing that the air extractor pipe (indicated with green) of the return chamber, ends up to the mist box (indicated with white square). Additionally the damaged valve to the fuel supply (yellow circle) is shown which caused the overflow of the return chamber.

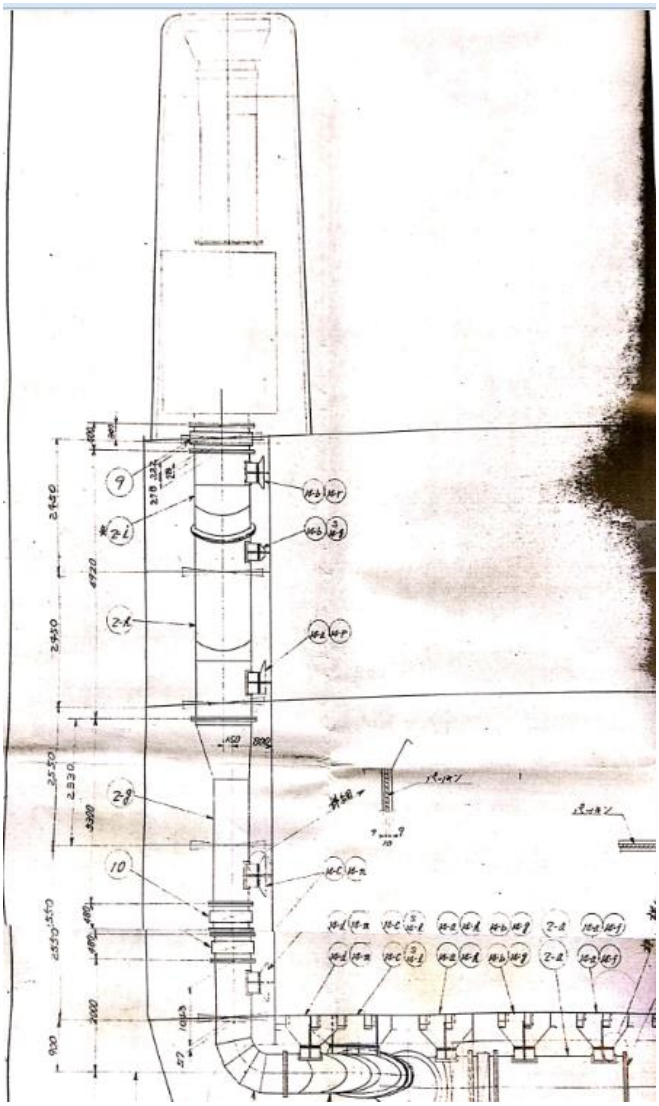

Figure 18: Capture of the port side funnel duct showing the exhaust gas pipe arrangement.

Consequently the engine personnel was unaware of this arrangement, in order to assess and implement in cooperation with the managing company, appropriate preventive measures to avoid any possible overflow leakage of fuel inside such a high risk area of the vessel, like the port funnel.

Moreover the above existing piping arrangement was not identified during the past surveys or noted in the relevant plan by the vessel's class, which issued also the statutory passenger ship safety certificate on behalf of the flag at the period of the accident, either during the initial/intermediate/renewal class surveys or during passenger ship safety annual surveys respectively, according to class rules and SOLAS applicable requirements as will be analyzed further in the following paragraph.

4.3.2 Measures to prevent fires in Engine rooms

Recent research coordinated by IMO[1] has indicated that between 30 to 50% of all fires on merchant ships originate in the engine room and 70% of those fires are caused by oil leaks from pressurized systems. However, it is also quite common for fires to originate from the overflow of low pressure fuel oil piping systems, like the one under investigation on IERAPETRA L.

[1] 1 Analysis of Fire Hazard and Safety Requirements of a Sea Vessel Engine Rooms, Adam Charchalis & Stefan Czy, *Journal of KONES Powertrain and Transport, Vol. 18, No. 2 2011*

Oil fires usually occur when oil from a large leak or a smaller but persistent leak comes into contact with a nearby hot surface at a temperature that exceeds the 'minimum auto ignition temperature' (MAIT)[2] of the oil. MAITs of diesel and fuel oil are typically about 250°C, but MAITs as low as 225°C exist[3]. Lube oils and hydraulic oils have somewhat higher MAITs. For heavy and intermediate oil liquids as for example F.O 180 used on board IERAPETRA L, possible sources of ignition, among others, include exposed parts of engine exhausts, turbochargers, boiler combustion chambers and thermal fluid pipes at a temperature exceeding the minimum auto-ignition temperature (MAIT) of the oil.

Preventing oil fires by using a safety device as described in par.4.3.1 is one protective measure, the other being effective insulation of hot surfaces so that they do not present a source of ignition if an oil leak occurs. This is possibly the most effective way to prevent engine room fires and fairly easy to implement. It is a SOLAS requirement that hot surfaces, with temperatures above 220°C that might come into contact with oil are properly insulated[4]. Therefore, crew and vessel's managers/owners should perceive that even a small exposed area of a non-insulated hot surface, such as part of a flange joint or a small part of the exhaust gases pipe can be potentially dangerous.

During the visit of the investigation team on board IERASPETRA L, the port side engine exhaust inside the funnel duct was checked to investigate any exposed parts that could come in contact with the fuel oil, in order to verify the ignition source. Unfortunately the intensity of the fire inside the port funnel destroyed large sections of the exhaust's pipe insulation, so no specific conclusions could be reached.

Figure 19: Part of the exhaust pipe inside the port funnel duct. The damaged insulation is visible in the lower part of the picture.

[2] When a flammable gas or vapour/air mixture is raised to a sufficiently high temperature it can ignite spontaneously, i.e. without an external source of ignition such as a spark or naked flame. This is known as the auto ignition temperature. For reasons of safety if the temperature of any surface (irrespective of its geometry or size) exceeds the reported MAIT of a fuel, a fire will occur.

[3] UK P&I Club –Engine room fires.

[4] Res.MSC.31(63)-Annex 2 "Amendments to International Convention SOLAS 74" Reg.II-2/15 par.2.10

Nevertheless by taking under consideration the sequence of events, as analyzed in the previous paragraph, the possibility that some parts of the exhaust pipe not being efficiently insulated, or the possibility the insulation not to cover all the surface of the exhaust pipe cannot be excluded. Consequently as the exhaust gases pipe is the only hot surface equipment passing through the port side funnel, the investigation concluded that this was in fact the only possible ignition source.

At the period of the marine casualty, "IERAPETRA L" was holding a valid Passenger Ship Safety Certificate (PSSC) for short international voyages according to SOLAS 74 as modified by protocol of 1988, and a Class certificate, both issued by Class. Under the above certification the vessel was complying with all applicable requirements of SOLAS Convention and relevant class rules. Indicatively on the PSSC certificate it was noted that:

"…the survey showed that the ship complied with the requirements of the convention as regards: the structure, main and auxiliary machinery, boilers and other pressure vessels;"

The last survey carried out for the issuance of the PSSC was the 17th of June 2014, that is almost five months before the accident, and the certificate was valid until the 24th of June 2015. Respectively the third annual class certificate and intermediate class surveys were carried out on the 17th of June 2014.

According to SOLAS 1996-1998 amend/ChapterII-2/Reg.1, it is stated that:

"Unless expressly provided otherwise, for ships constructed before 1 July 1998 (i.e IERAPETRA date of build 31/05/1975) the Administration shall ensure that the requirements which are applicable under Chapter II-2 of the International Convention for the Safety of Life at Sea, 1974, as amended by resolutions MSC.1(XLV), MSC.6(48), MSC.13(57), MSC.22(59), MSC.24(60), MSC.27(61) and MSC.31(63), are complied with.

The respective IMO Res.MSC.1(XLV), under Chapter II-2, titled "CONSTRUCTION-FIRE PROTECTION, FIRE DETECTION AND FIRE EXTINCTION" and specifically Regulation 15 titled "Arrangements for oil fuel, lubricating oil and other flammable oils", in paragraph 2.7 (oil fuel arrangements) stipulates that:

"Provision shall be made to prevent overpressure in any oil tank or in any part of the oil fuel system, including the filling pipes. Any relief valves and air or overflow pipes shall discharge to a position which, in the opinion of the Administration, is safe"

Respectively according to applicable Class rules it is stated that[5]:

".Fuel oil systems are to be so designed as to prevent:

- overflow or spillage of fuel oil from tanks, pipes, fittings, etc.
- fuel oil from coming into contact with sources of ignition

[5] Rina Class rules Part C, "Machinery Systems &Fire Protection" Chapter 1, Section 10, par.11.2.1sub.par(b)

- overheating and seizure of fuel oil……."

Moreover under Part C, Chapter 1, Section 10, par. 9.1.7 of Class rules titled "Special arrangements for air pipes of flammable oil tanks (1/7/2004)" it is stated that:

"Air and overflow pipes and relief valves of fuel oil and thermal oil systems are to discharge to a position on the open deck where there is no risk of fire or explosion from the emergence of oils and vapour."

Additionally under the same section titled "Piping Systems", general and specific requirements applying to all piping systems are specified regarding among others:

- their design and construction
- the welding of steel pipes
- the bending of pipes
- their arrangement and installation
- their certification, inspection and testing.

As part of the documents required to be submitted for approval to the Class are the plans of the air, sounding and overflow systems as well as a Diagram of the fuel oil system.

Taking into account the above international legislative and Class rules relative framework in conjunction with the analysis as presented in the previous paragraphs of this investigation report, it is concluded that the air ventilation pipe of the return chamber should not have been designed to end inside the port side funnel duct, bearing in mind the absence of efficient insulation on the surface of the exhaust gases pipe, and the absence of any other safety appliance in order to monitor the overflow inside the return chamber or at its air extractor pipe. This design error is considered as a contributing factor to the marine casualty.

4.3.3 Verification on proper setting and operation of the critical equipment after maintenance

In common practice, maintenance carried out on a vessel's critical equipment such as the main engines and associated fuel oil supply system, is usually followed by verification that all equipment have been set, in their initial operating state so as to operate as intended. Such verification is usually conducted by indicator diagrams or other operational tests and evaluation of the proper parameters (operational temperatures, pressures, noise, power output, fuel consumption, etc).

Also a test operation is usually conducted, where the engines' and systems' proper operation is tested at various loads.

In the case of IERAPETRA L, according to the vessel's records during the maintenance works there were 2 inspections carried out. The first one was on the 18th of October 2014, by an independent technical office, while the 2nd one was the internal audit according to the SMS provisions (ISM internal audit) on the 24th of October 2014. However, both of them were not focused on the maintenance carried out on the port main engine, nor the correct setting and operation of the engine's fuel oil supply equipment was verified.

In fact maintenance works were well conducted after these inspections, but no tests or other verification methods were performed after the end of the maintenance and prior to the vessel's

departure to Igoumenitsa, to ensure the proper operation of the engines and all associated auxiliary equipment.

4.4 Human and organizational factors

4.4.1 Processes in place for verification after maintenance

Maintenance is part of the normal tasks carried out by the crew on board a vessel like IERAPETRA L, especially when she is idle. However the complexity of such works is variable according to the nature of the maintenance and the equipment or the machinery involved.

It appears that the crew involved in conducted the maintenance tasks in particular on the port main engine were quite experienced and familiar with the tasks in hand. Yet, there are parameters affected when maintenance tasks are being conducted which require verification after the works are concluded. Records of actions during maintenance usually help in the checks of such parameters, for example when the setting of any valve is altered during maintenance, and this is recorded, it will make easier to set back to the normal operating condition after works are over.

Recording of actions during maintenance would also ensure that whenever there are changes in the personnel of the engine room, the risk of inappropriate handover and in particular the risk of a critical valve left in a position which will affect the normal operation of the vessel and its machinery will be eliminated.

In the investigated case, the verification of the normal operation of the fuel oil supply system concerning the flow of the fuel's oil return and in particular on checking the setting of the Return Chamber's valve, which was found damaged and closed during maintenance, was not carried out as identified by the evidence gathered. Additionally, no such processes had been recorded and subsequently no relevant actions for the follow-up of the proper function of the port's main engine fuel oil return system were carried out after the maintenance at Brindizi port and prior the departure to Igoumenitsa.

Therefore, it is deemed necessary for the vessel's company, in order to secure the safety of operations on board, to have a procedure in place, so as to record and monitor the proper setting and operation of all machinery and equipment which have undergone maintenance by the crew, prior to departure from port.

Moreover, the absence of a fuel level detector at the Return Chamber or of any other overflow alarm at its associated air extractor pipe, did not allow the crew on watch in the engine room to apprehend the situation and take appropriate measures to eliminate the danger before the fire broke out.

4.4.2 Emergency response

Although most of the crew members came on board on the day or a few days before the departure from Brindizi, their familiarization had been carried out. In fact the crew cooperated and responded in an effective way during the emergency and until the vessel's safe return to Brindizi, according the procedures in place for emergency response.

4.4.3 Working – rest time on board

The vessel's crew was according to the requirements of the minimum safe manning document issued for the specific voyage (without passengers and cargo on board). From the relevant records examined, it did not appear to be any factors related to work and rest periods for the crew on board, as the vessel had just departed the port of Brindizi after a period of over one month of idleness.

5. Actions Taken
5.1 Actions Taken by the Company

The previous as well as the current owners/managers of the vessel, did not respond to HBMCI's request during the consultation period, to report any corrective actions taken to prevent reoccurrence. However during a visit of the investigation team on board[6], it was observed that the current company of the vessel had taken some preventive measures to ensure that, fuel oil will not end up again inside the port side funnel duct. The return valve to the fuel supply of the main engines was secured at the open position, using a chain and lock. Additionally an overflow measuring device was installed at the air extractor pipe of the return chamber, fitted with an alarm positioned at the engine room control panel, to warn engine personnel in case of overflow.

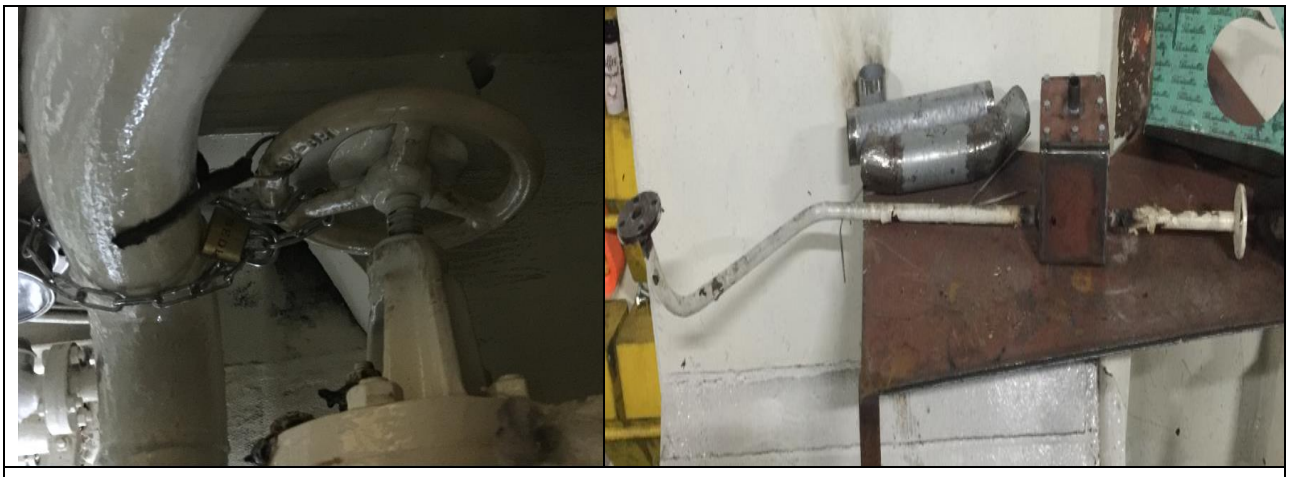

Figure 20: Left :The return valve secured with a chain and lock. Right: The alarm monitoring device ready to be fitted at the air extractor pipe of the return chamber.

The following conclusions, safety measures and safety recommendations should not under any circumstances be taken as a presumption of blame or liability.
The juxtaposition of these should not be considered as an order of priority or importance.

6. Conclusions

6.1 Fuel spray around the area of the port funnel indicated that there was fuel overflow, deriving from the port main engine's systems. (§4.2)

6.2 The design and construction of the Return Chamber and its associated air extractor pipe included a high risk factor in terms of control of overflow, while no level detector or other overflow alarms were in place for such a case. (§4.3.1 and 4.4.1)

6.3 The valve from the Return Chamber to the fuel supply system of the vessel was found damaged, at closed position most possible (without being recorded) during maintenance (§4.3.1)

6.4 Maintenance carried out on the port main engine, was not followed-up with verification tests of the proper function of the fuel's oil return system. (§4.3.2 and 4.4.1)

6.5 The fire was caused by the overflow of fuel oil from the port main engine's Return Chamber which was led through the air extractor pipe within the port funnel duct where it came in

[6] 31-05-2019

contact with the hot surfaces of the main exhaust gas pipe which were most probably insufficiently insulated. (§4.3.3)

6.6 No process or procedure was recorded on board to set (when necessary) the actions for verification of proper and safe operation of machinery equipment after maintenance. (§4.4.1).

6.7. The design error concerning the upper edge of the air ventilation pipe of the return chamber constructed in an high risk area of the ship (inside the port side funnel duct), was neither identified during statutory and class surveys carried out in the past nor marked accordingly on the vessel's drawings. Consequently engine personnel were unaware of this piping arrangement and could not assess and implement any preventive measures to monitor any possible overflow. (§4.3.1-4.3.2)

7. Safety Recommendations

Taking into consideration the analysis and the conclusions derived from the safety investigation conducted in conjunction with the Actions taken by the ship's Company after the marine casualty, HBMCI decided to issue the following recommendations on this accident:

7.1 The ex-company of IERAPETRA L is recommended to:

63/2014: review its Safety Management Manual fleet wide, in order to ensure that testing and verification of the proper setting and operation of all machinery and associated equipment on a vessel, such as the one examined in the current investigated case, are carried out whenever they undergo maintenance and prior to departure ***(Con.6.3-6.4-6.6)***

7.2 The company of AQUA BLUE (ex IERAPETRA L) is recommended to :

64/2014: take preventive measures in consultation with the vessel's class and relative authority issuing the PSSC in order to ensure that in case the Return Chamber overflows, the fuel will not be led within the air extractor pipes that exist within the funnel ducts of the vessel, as it happened in the examined case. Additionally to check preventively all other tanks that contain fuel and have air extractor pipes that end up within the funnel ducts or in areas which according to the opinion of the Administration are not considered safe and act accordingly **(Con.6.2-6.5-6.7)**

7.3 Classification society is recommended to:

65/2014: reassess the procedures concerning the approval of the machinery drawings of their classed vessels in order to verify that they correspond with actual arrangements found on board and comply with applicable class rules and statutory requirements**.(Con.6.2-6.5-6.7)**

7.4 Ship's Control General Directorate of the Greek Administration through its Directorates is recommended to:

66/2014: Notify the ROs and Local Inspection Offices of the Port Authorities, as the issuing Authorities of Passenger Ship Safety Certificates to examine if a similar piping arrangement is fitted on other Ropax vessels under the Greek flag, and take if necessary, appropriate measures to prevent reoccurrence. **(Con.6.2-6.5-6.7)**

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Accident Investigation Report 10/2014
Hellenic Bureau for Marine Casualties Investigation
150 Grigoriou Lambraki Str.,
Postal Code: 18518, Piraeus, Greece
Tel.: +30 213 4191970
FAX: +30 213 4191269
E-mail: hbmci@yna.gov.gr
Website: http://hbmci.gov.gr