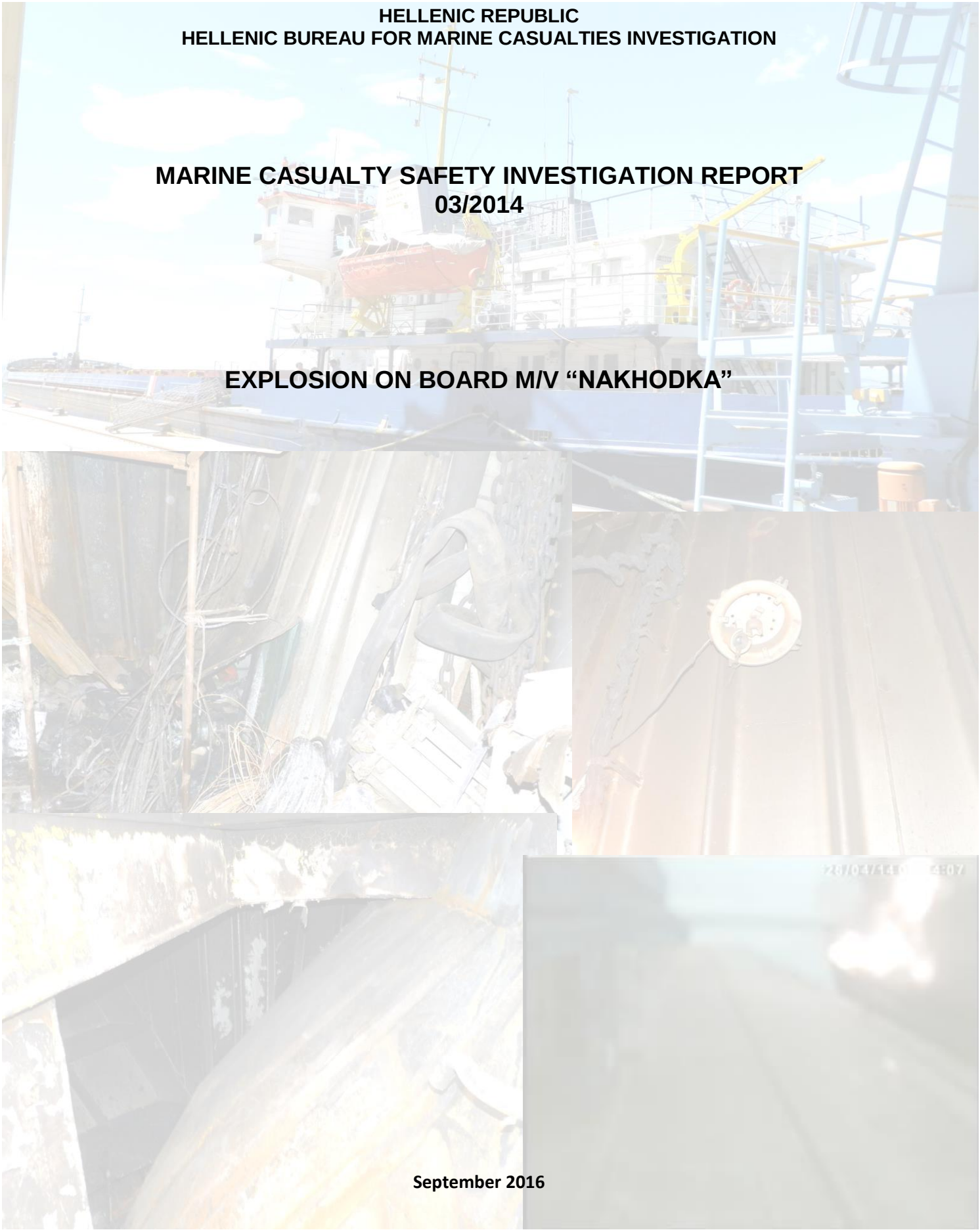

HELLENIC REPUBLIC
HELLENIC BUREAU FOR MARINE CASUALTIES INVESTIGATION

MARINE CASUALTY SAFETY INVESTIGATION REPORT 03/2014

EXPLOSION ON BOARD M/V “NAKHODKA”

September 2016

Contents

GLOSSARY OF ABBREVIATIONS AND ACRONYMS		
1.	HBMCI	Hellenic Bureau for Marine Casualties Investigation
2.	IMO	International Maritime Organization
3.	SOLAS	Convention for the Safety of Life at Sea 1974, as amended
4.	ISM	International Management Code for the safe operation of ships and for pollution prevention
5.	SMS	Safety Management System
6.	SMM	Safety Management Manual
7.	UTC	Coordinated Universal Time
8.	Bf	Beaufort (wind force measuring unit of Beaufort Scale)
9.	HP	Horse Power
10.	Lt - Ltrs	Liter - Liters
11.	m	meters
12.	AB	Able seaman
13.	M/V	Motor Vessel
14.	CoC	Certificate of Competency
15.	HCG	Hellenic Coast Guard
16.	RMRS	Russian Maritime Register of Shipping
17.	CCTV	Closed Circuit Television
18.	EMSA	European Maritime Safety Agency

Foreword

The Hellenic Bureau for Marine Casualties Investigation 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 ascertain the circumstances and contributing factors that caused it through analysis 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 or avoid 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 the events that occurred on the 24th of April 2014 and resulted in the examined very serious marine casualty and aims to prevent and deter repetition.
Fragmentary or partial disposal of the contents of this report, for other purposes than those produced 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 local times (UTC +2) unless otherwise stated.
Under the above framework HBMCI has been examining the circumstances of an explosion occurred on board M/V NAKHODKA, resulting in the fatal injury of one seaman and the serious injury of another.

1. Executive summary

M/V NAKHODKA loaded with grain from Rostov (Russia), arrived at the port facility of Loulis Mills at the area of Sourpi near Amaliapolis, Volos on the 25 April 2014 to discharge her cargo.
The following day of her arrival, at approximately 08:00 on 26 April 2014, the Chief Engineer along with the 3rd Engineer went to the Boatswain's Store, located at the vessel's forecastle, to mend a pipe. At approximately 08:04 there was an explosion inside the forecastle, followed by the outbreak of fire inside the Boatswain's Store as well as at the adjacent space of the Paint Room, situated at the port side of the forecastle.
The crew of NAKHODKA was alerted, mustered on scene and efforts were made to extinguish the fire by spraying water with the fire hoses. The explosion was noticed by the crew of an adjacently berthed vessel and the Mill's security personnel who immediately reported the incident to the local Coast Guard Authority. A local Fire Brigade Squad arrived on scene shortly afterwards and managed to extinguish the fire, limiting its potential growth to other areas of the vessel.
The Chief Engineer as well as the 3rd Engineer suffered extended burns on their bodies and inhalation burns due to the explosion and were transferred to a local hospital for medical treatment. However, their condition was critical and during the same day they were transferred to another specialized hospital.
As stated above the medical condition of the two crew members was critical and finally the Chief Engineer passed away in the hospital almost one month after the date of the explosion. The 3rd Engineer managed to recover and exited the hospital on the 21st of June and was repatriated.
The vessel sustained damages due to the explosion and the fire, in the forecastle, such as distortion of bulkheads and burning of equipment.

2. Factual information

2.1. Vessel´s details

Name of Vessel	NAKHODKA
Flag State	Russia
Port & No of Registry	Taganrog 774142
Call Sign	UBLV
Type of Vessel	General Cargo
IMO Number	7807031
Loa (Length over all)	108,40 m
Breadth	14.80 m
Year built	1978
Place built	Oltenitsa, Romania
Hull material	Steel
Gross Tonnage	2441
Net Tonnage	917
Classification Society	Russian Maritime Register of Shipping (RMRS)
Main Engine	2 x Magdeburg 6NVD 48A – 2 U/ 700 HP
Minimum Safe Manning	11
Trading Area	International (A1, A2, A3)

Figure 1: M/V NAKHODKA berthed at the port facility of LOULIS MILLS, at Amaliapolis.

2.2. Voyage details

Vessel´s name	NAKHODKA
Port of departure	Rostov (Russia)
Port of arrival	Loulis Flower Mills, Amaliapolis, Volos, Greece
Type of voyage	International
Cargo	Grain
Crew on board	11

2.3 Marine casualty information

Vessel´s name	NAKHODKA
Type of casualty	Very serious
Date and time	26-04-2014, at approx.08:04
Position – location	lat: 039° 09´ 56,18´´ N - long: 022° 52´ 09,57´´ E (Port facility of Loulis Mills, Amaliapolis, Volos)
External environment	Daylight, medium visibility, wind force 3 Bf, variable wind direction
Ship operation	Berthed
Consequences (to individuals, environment, property)	• Severe burns to 2 crew members (one passed away while hospitalized, one recovered) • Buckling and cracking of the central longitudinal bulkhead of the forecastle between the Paint Room and the Boatswain's Store, buckling of exterior doors of the forecastle's spaces, burnt equipment inside the forecastle's spaces.

2.4 Emergency response actions and shore Authorities involvement

Following the explosion the port facility personnel reported the incident to the Coast Guard Authority of Amaliapolis. The Coast Guard Authority launched the "Emergency Response Plan" and deployed one vehicle with two Officers to the area of the casualty. In parallel they notified the Fire Brigade and the National Emergency First Aid Centre. The local Fire Brigade deployed 4 manned fire trucks and extinguished the fire.
The injured crew members were transferred to the local hospital by means of a port facility's vehicle following advice from the National Emergency Aid Center.

Authorities – Services involved		
Port facility	→	1 vehicle utilized for the transferring of the casualties to the local hospital
HCG	→	1 vehicle manned with two Officers
Fire Brigade	→	4 manned fire trucks

3. Narrative

3.1 Arrival at the port of Amaliapolis

On 25 April 2014, at approximately 12:15, M/V NAKHODKA loaded with grain cargo from Rostov, Russia arrived at the port facility of Loulis Mills, at the area of Sourpi near Amaliapolis, Volos, Greece, and moored safely. According to the schedule, the cargo discharging operations would start the next morning, using the port facility's cranes.
It was reported that the weather conditions were good. After the completion of the daily work most of the crew members went to rest as no task was scheduled to be performed until the next day's morning hours.

3.2 The explosion

In the morning hours of the 26 April 2014, the Chief Engineer along with the 3rd Engineer went to the forecastle of the vessel for repairing a steel pipe of the vessel's diesel generator engine which was leaking. The repair work would be carried out at a work bench situated at the port side of the Rope Store inside the forecastle as there was no workshop at the vessel's engine room (figure 2).
It is noted that during the interview process, the crew members of NAKHODKA could not provide any information with regard to the working process for the repairing of the pipe and whether hot works were to be carried out by the two engineers.

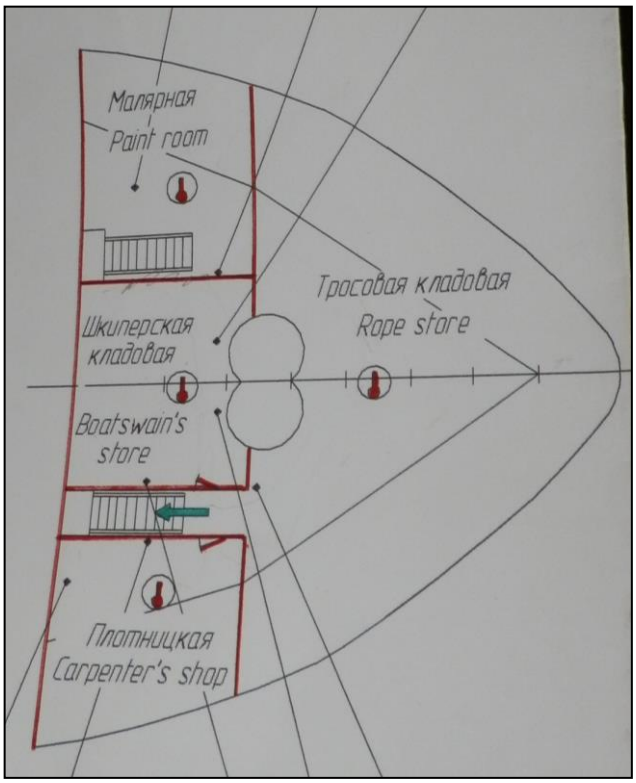

Figure 2: The interior of the forecastle. The mending of the pipe would be carried out by the Chief and 3rd Engineer inside the rope store. *(Source: M/V NAKHODKA's Fire Control Plan, No:53025)*

The exact time of the entry of the two seamen in the Rope Store could not be determined, as no member of the crew could specify it. However, the last man to see them was the AB performing the 08:00 – 12:00 deck watch (vessel's time)[1] at the vessel's gangway. He reported that shortly before the explosion the two crew members told him that they were going to the forecastle to repair a pipe and proceeded through the starboard side of the deck. He also reported that they didn't carry with them any tools.

Figure 3: The companion way ladder leading from the starboard watertight door of the forecastle to the internal passageway.

The Rope Store was accessible through a watertight door at the starboard side of the forecastle's aft bulkhead and through a companion way ladder leading to a passageway between the Carpenter's Shop and the Boatswain's Store (Figure 3).

[1] The vessel was operating under the Russian Time (UTC+3). Therefore the 08:00 – 12:00 watch (vessel's time) corresponds to 07:00 – 11:00 Local time.

At 08:04:05, as recorded by the port facility's CCTV, an explosion occurred inside the forecastle's spaces. The location of the initial explosion was determined to be at the starboard side of the forecastle, while it was followed by a stronger second explosion at the port side of the Boatswain's Store. The fire outbroke inside the Boatswain's Store and the adjacent Paint Room compartment (Figures 4,5).

Figure 4: Screenshots of the recorded video by the port facility's CCTV at 08:04:05, indicating the flame from the initial explosion at the starboard side, followed by a secondary blast at the port side.

Figure 5: Screenshots of the recorded video by the port facility's CCTV during 08:04:05 – 08:04:07, indicating the higher energy of the secondary explosion at the port side.

3.3 Consequences of the explosion

The second explosion cracked the bulkhead between the Paint Room and the Boatswain's Store, in the direction from the Boatswain's Store to the Paint Room. The explosion's heavy blast forced open and deformed the watertight door of the Paint Room which was closed and locked, and a fire broke out at the two aforementioned compartments. The explosion's blast wave casted parts of metal components and vessel's equipment in the forecastle area as well as overboard (Figures 6,7).

The outbreak of the fire was evident by the emission of smoke from both forecastle's doors as the starboard side watertight door was left open when the two engineers entered.

Right after the explosion, the Chief Engineer and the 3rd Engineer exited the forecastle from the starboard side door. Their clothes were burnt, emitting smoke and they were suffering of extended burns on most parts of their bodies.

According to the RMRS 's report for the casualty the damages of the vessel were as follows:

"a crack in the watertight bulkhead, fr.15, CL, at the height of 2m from the double bottom, length: 2m; paint room watertight door has been deformed; carpenter shop bulkhead has been deformed without destruction; corrugated bulkhead and ladder of paint room have been destroyed from the deck in the boatswain and rope stores and heavily deformed; boatswain's stores deck was damaged; windlass cable feed was damaged."

The vessel undertook temporary repairs for a direct passage to a repair port in Izmail, Ukraine where by the 12th of May 2014 all damages had been permanently repaired, and the vessel retained her class.

Figure 6: Capture of the cracked bulkhead of the Paint Room after the extinguishing of the fire. It is evident that the intermediate (between Paint Room and Boatswain's Store) bulkhead has been heavily buckled by the explosion, blocking the access to the lower space, while the door has been deformed by the explosion gases.


Figure 7: Metal pieces found overboard, casted by the explosion

3.4 Actions after the explosion

The sound of the explosion alerted the crew of NAKHODKA, as well as the crew of a nearby moored vessel and the port facility's personnel.

The Chief Mate activated the fire alarm and rushed to the bow with some other crew members to assess the situation.

At approximately 08:15, the crew started the fire extinguishing operation. The 2nd Engineer and the Electrician started the main and emergency fire pumps while other crew members started spraying water to the fire with two fire hoses.

The Master and the Cook offered first aid to the casualties who had exited from the forecastle with severe burns on their bodies.

The Port Facility's personnel reported the marine casualty to the Coast Guard Authority of Amaliapolis who notified the Fire Brigade. Subsequently, the agent of NAKHODKA notified the Fire Brigade following Master's request.

When the HCG Officers arrived on scene, they contacted with the National Emergency Aid Centre, to arrange the transfer of the injured engineers to the hospital. However, considering the condition of the injured crew members it was decided to avoid any delays. Therefore they were covered with sheets and transferred to the local hospital with a vehicle of the Port Facility.

At approximately 08:40, the Fire Brigade's firefighting trucks arrived on scene and started the fire extinguishing operation, which lasted until 13:30 successfully distinguishing the fire.

Figure 8: Photo of the cooling process after the extinguishing of the fire on board NAKHODKA by the Fire Brigade.

3.5 Injured crew members' medical treatment

The injured Chief Engineer and the 3rd Engineer were offered first aid by the Cook and the Master holders of First Aid Certificate. They were also covered with clean sheets as their clothes had been burnt.

Then they were transferred to the local hospital of Volos, by Port Facility's vehicle. The two seamen suffered multiple burns on their face, head, hands and feet, back and thorax as well as inhale burns. They were intubated and they were transferred to a specialized hospital in Athens on the same day. Both of them remained in the Intensive Care Unit.

However, the Chief Engineer's condition deteriorated and finally he died in the hospital on 23 May 2014 due to multiorgan inefficiency.

The 3rd Engineer managed to recover from his burns and exited the hospital on 21 June 2014 and was repatriated on the same day.

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 investigation information in order to draw useful conclusions leading to safety recommendations.

It is noted that during the investigation process the majority of the information derived from the interviewing process and the examination of the forecastle spaces after the extinguishing of the fire.

4.1 General arrangement of the forecastle

The forecastle area comprised four separate spaces (see Fig.9). The Paint Room was situated at the aft port side and it was accessed through a watertight door and a companion way ladder. The Paint Room was equipped with a fixed CO_2 fire extinguishing system. The two CO_2 cylinders were located on the main deck, at the starboard side of the Paint Room door.

A second watertight door was located at the Starboard side of the forecastle that was leading to a passageway through a companion way ladder. At the port side of the passageway a door was leading to the Boatswain's Store situated in the middle aft part of the forecastle, while a door at

the port side of the passageway was leading to the Carpenter's Shop section situated at the Starboard aft part of the forecastle.

The passageway was leading to the Rope Store situated at the fore part of the forecastle until the vessel's stem post.

According to the vessel's Fire Control Plan the aforementioned spaces formed "Class A divisions[2]", hence the access doors to the Boatswain's Store and the Carpenter's Shop were considered of "Class A" as well.

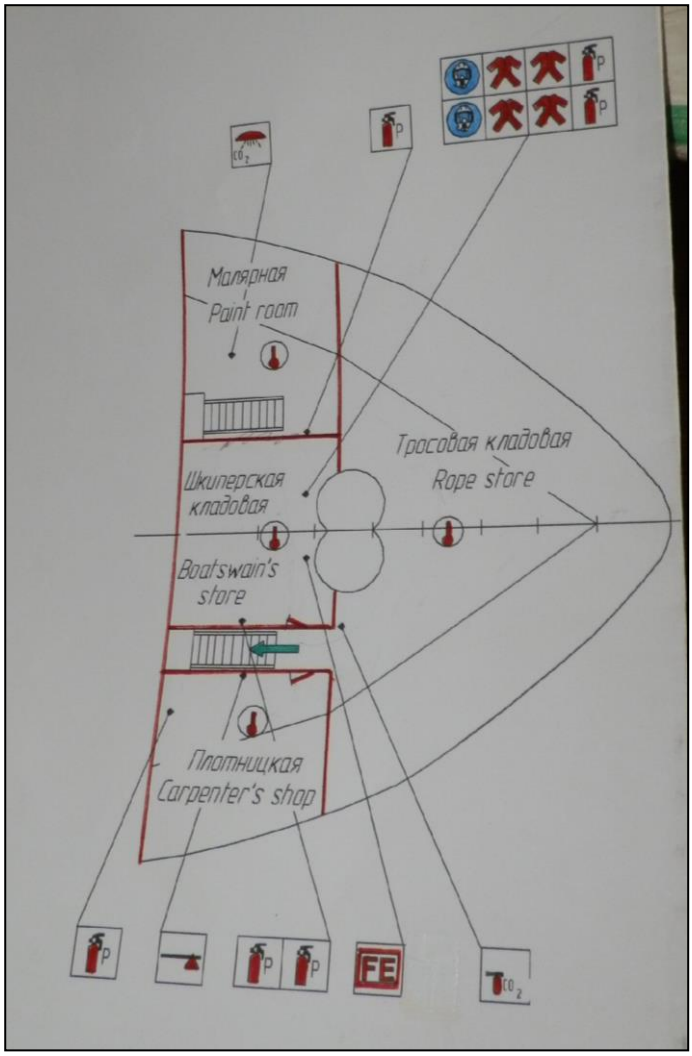

Figure 9: The forecastle area as presented by the vessel's Fire Control Plan (No 53025)

[2] SOLAS 60 Chapter II, Part D, Reg 35.

" A " Class or Fire-resisting Divisions are those divisions formed by bulkheads and decks which comply with the following :

(i) they shall be constructed of steel or other equivalent material;

(ii) they shall be suitably stiffened;

(iii) they shall be so constructed as to be capable of preventing the passage of smoke and flame up to the one-hour standard fire test;

(iv) they shall have an insulating value to the satisfaction of the Administration, having regard to the nature of the adjacent spaces. In general, where such bulkheads and decks are required to form fire-resisting divisions between spaces either of which contains adjacent woodwork, wood lining, or other combustible material, they shall be so insulated that, if either face is exposed to the standard fire test for one hour. The average temperature on the unexposed face will not increase at any time during the test by more than 250°F. (or 139°C.) above the initial temperature nor shall the temperature at any point on the face, including any joint, rise more than 325°F. (or 180°C.) above the initial temperature. Reduced amounts of insulation or none at all may be provided where in the opinion of the Administration a reduced fire hazard is present. The Administration may require a test of an assembled prototype bulkhead or deck to ensure that it meets the above requirements for integrity and temperature rise.

4.2 Access of crew to the forecastle

During the interview process it was reported that the doors of the forecastle were kept locked and the AB who was also performing the Boatswain's duties had the keys. When a crew member had to enter the forecastle spaces, he would inform the Boatswain. Consequently, the Boatswain would report to the Chief Officer and the Master the names of the requesting crew and the purpose of entry, and the Master would approve the access. Nonetheless, said procedure was not confirmed by all the crew members and it was not incorporated or documented in any of the vessel's procedure manuals. Furthermore, no respective records or other documentation were kept by the vessel's crew.

On the day of the accident the AB who was also performing the Boatswain's duties was on duty at the vessel's shore gangway from 07:00. The AB was the last man who saw the two Engineers before they entered the forecastle. Before the explosion the two crew Engineers told him that they were going to the forecastle to repair a pipe and proceeded through the starboard side of the deck, without carrying any tools with them.

In light of the above it is suggested that the day of the casualty the two engineers entered the forecastle to repair a pipe form the vessel's D/G without following any specific procedures and without informing the Master.

4.3 Cause of the explosion

4.3.1. Autopsy findings after the fire extinguishing

After the explosion and the extinguishing of the fire, the forecastle area was inspected by the authorities as well as by the HBMCI investigation team that boarded NAKHODKA on 29 April 2014, that is 3 days after the casualty. The findings of the aforementioned inspections are presented in the following paragraphs.

.1 <u>The Paint Room</u>

The Paint Room had sustained severe damages due to the explosion and the fire. The bulkhead between the Boatswain's Store and the Paint Room had been damaged mostly, as it had been cracked at its bottom and bended towards the Paint Room. Moreover, the watertight door of the Paint Room was deformed as it was forced open due to the explosion's blast.

Some paint buckets were found inside the Paint Room. The exact quantity of paint that was stored in the Paint Room prior to the explosion could not be identified; however based on the consequences of the explosion it could not be considered as a significant quantity for the creation of an explosive atmosphere (Figure 10).

Figure 10: The bended bulkhead and the paint buckets found inside the Paint Store.

.2 The Boatswain's Store

The Boatswain's Store was damaged by the explosion and the fire, while several materials and equipment were burnt and spread on the floor. The Boatswain's Store had a storage section used to store firefighting equipment including fire extinguishers and air breathing apparatus cylinders as well as other materials and equipment such as wires, ropes, etc. However none of them could be related to the cause of the explosion as they do not produce vapors that could form an explosive environment when mixed with air (Figure 11).

Figure 11: The Boatswain's Store after the explosion showing the storage section selves

.3 The Carpenter's Shop

No signs of the explosion, fire or burnt material were found in the Carpenter's Shop. The equipment and material stored inside was found intact and in good condition, indicating that the explosion and the fire of the examined marine casualty did not affect it (Figure 12).

Figure 12: Equipment and materials stored inside the Carpenter's Shop.

However, in said compartment one propane cylinder and two oxygen cylinders were found placed in it. The propane cylinder was connected to a flexible pipe almost 30m long, which at the other end was connected to a flame tool found on the work bench at the port side of the Rope Store. After the fire was extinguished the propane and oxygen cylinders were removed by the crew members of NAKHODKA, who assisted the Fire Brigade personnel and were placed on the deck. During said process it could not be established if the propane cylinder valve handwheel was open or closed. The propane cylinder was weighted by the HBMCI investigation team and was found almost empty (Figures 13, 14).

Figure 13: The two oxygen (blue) and one propane (red) cylinder that were carried from the Carpenter's Shop to the open deck, after the fire extinguishing operation. The flexible pipe that was connected to the cylinder before it was cut in order to remove it is marked.

Figure 14: The weighting of the propane cylinder. Its weight was scaled at 23.38kg. The tare weight (empty bottle) was 22kg marked on the cylinder, while the total weight (full bottle) was 43.7kg.

The Carpenter's Shop compartment had clear signs of explosion incident in the past. More specifically the port bulkhead of the space was bended towards the passageway, while the door casing was cracked and the door was deformed and could not be closed. Additionally, although the door was constructed to open towards the inner side, as indicated in the Fire Control Plan, the door remained open towards the outer side of the compartment. Furthermore, cracks were found on the door and the door casing with deep oxidation signs which could not be attributed to the water spraying efforts to extinguish the fire as these efforts were targeted inside the Paint Room (Figures 14,15).

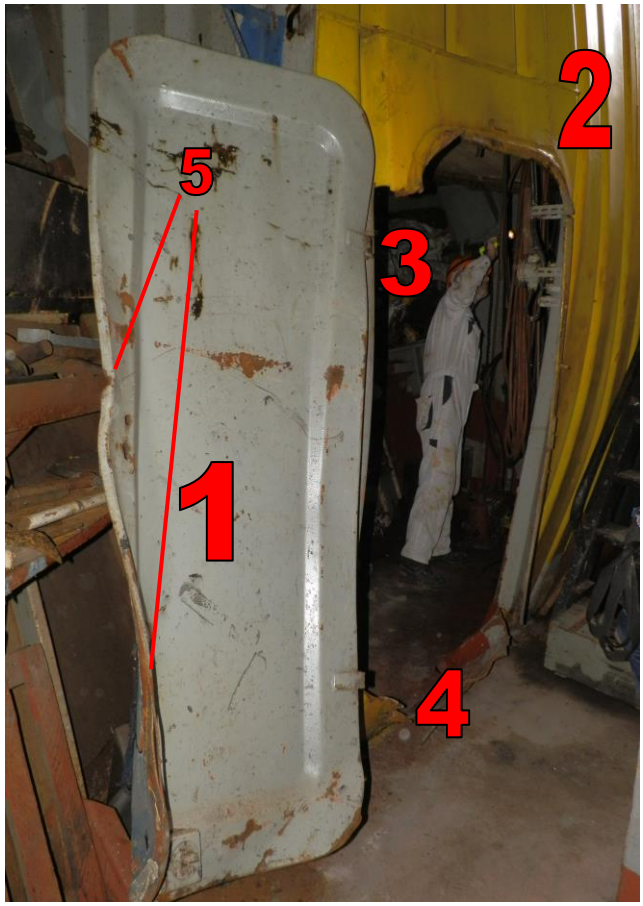

Figure 14: The door of the Carpenter's Shop (1) and the internal bulkhead (2). They were evidently deformed, while there were cracks on the door's casing (3) and (4). The paint coating was clear and in good condition. The deep corroded points on the door (5) and at the lower casing (4) cannot be attributed to the oxidation from extinguishing water sprays suggesting that the occurrence had happened quite some time ago.

Figure 15: The door and the Starboard bulkhead of the Carpenter's Shop, clearly deformed, yet thoroughly painted.

.4 The Rope Store

Inside the Rope Store a work bench was placed at the port side. One more oxygen cylinder was found near the bench connected to the flame tool which was found on the bench. Moreover, according to Fire Service's Officers, a welding machine was placed in the Rope Store; however its cables were stored indicating that it was not in use at the time of the accident (Figure 16).

Figure 16: The Rope Store as found after the explosion. On the left upper corner of the picture the working bench is shown, while an oxygen cylinder connected to the flexible pipe of the flame tool lies on the floor.

.5 Electrical lighting equipment

The electrical lighting equipment installed in all spaces of the forecastle was of enclosed type; nonetheless it was evident that additional electrical connections were used by the crew. More specifically an extension cable was found connected inside the Store leading to an open unprotected lampholder above the door of the compartment (Figure 17).

Figure 17: The connection at the entrance of the forecastle and the open lampholder found above of the Boatswain's Store door.

4.3.2 Explosion analysis

The analysis of the explosion in the forecastle of NAKHODKA for the identification of its causes, is oriented to the examination of two preconditions: the creation of an explosive atmosphere[3]; and the ignition source that ignited the explosive mixture.

4.3.2.1 Explosive atmosphere by paints or paint solvents

Considering the flame outspread of the explosion as recorded by the port facility CCTV and presented at par. 3.2, it is inferred that an explosive atmosphere was created inside the forecastle mostly in the passageway area and inside the Boatswain's Store. The first blast indicates that the initial ignition occurred close to the passageway while the second blast as well as the extended damages of the bulkhead between the Paint Room and the Boatswain's Store, indicates that the second and more powerful explosion occurred at the Starboard side of the Boatswain's Store.

In view of the above, it is inferred that the major quantity of the dangerous substance which was mixed with the air and created the explosive atmosphere had been accumulated at the lower levels of the Boatswain's Store close to the bulkhead between the Paint Room and the Boatswain's Store.

Based on the findings of the inspections in the forecastle compartment after the fire was extinguished, as presented in paragraph 4.3.1, it is derived that the dangerous substances that were found in the four spaces of the forecastle and could create an explosive atmosphere were the paints and the propane. However, paint buckets were found only in the Paint Room and their quantity was not considered significant.

Furthermore, it was reported that the paints and their solvents were stored only in the Paint Room, while no other evidence was found "on scene" that could lead to a reasonable assumption that the paints' or their solvents' VOCs[4] created the explosive atmosphere.

On the above grounds the creation of the explosive atmosphere by vapors of paint or paint solvents (White spirit, thinner etc) could be excluded.

4.3.2.2 Explosive atmosphere by propane

Propane is considered a flammable gas (IMDG UN No: UN1978, Hazard Class: 2.1). The combustion characteristics of propane are presented below[5]:

Propane properties	
Lower Limit of Flammability (% in air)	2,15
Upper Limit of Flammability (% in air)	9,60
Flash Point	-104°C
Ignition Temperature in Air	493-549°C
Maximum Flame Temperature	1979°C
Specific Gravity of gas (air = 1.00)	1,52

When used in cylinders, propane remains under pressure in liquid form, but quickly becomes gas (vaporizes), when released in the air.

Propane becomes a vapor at temperatures above -104°C. However, for the ignition of the propane vapor the right mix of air and vapor (from 2.15% to 9.60% in air) should be attained. Bearing a molecular mass of 44 which is heavier than the main components of air, the propane gas is heavier than air and therefore it will accumulate at the lowest spaces. Propane itself is

[3] A mixture of dangerous substances with air, under atmospheric conditions, in the form of gases, vapours, mist or dust in which, after ignition has occurred, combustion spreads to the entire unburned mixture.

[4] Volatile Organic Compound: *any organic compound having an initial boiling point less than or equal to 250°C measured at a standard pressure of 101,3 kPa;* (EU Directive 2004/42/EC)

[5] In this paragraph information has been used from the following sources:

1. http://www.propane101.com/propaneliquidandvapor.htm
2. http://www.propanecouncil.org/learn-about-propane/facts/

colorless and odorless; however most propane fuels include an odorant, almost always ethanethiol, so that people can easily smell the gas in case of a leak. If propane is vented to the outside air, it will quickly dissipate with the slightest movement of air. Conversely, if propane is vented into an enclosed structure with no air movement, the propane vapor will concentrate on the floor and rise vertically if more propane is vented into the structure.

It is estimated that 1 lt of liquid propane will produce over 270 lts of vapor and this vapor will settle at the lowest possible levels. The propane vapors' level continues to rise if more propane is released and mixed with the air. The vapors may ignite if they find a source of ignition, such as open flame or spark.

In light of the above, as well as the data referred to par. 4.3.1.3 and 4.3.2.1, it is inferred that the explosive atmosphere was created by a leakage of propane. Based on the evidence collected during the investigation process the leakage point of the propane could not be identified; however considering the good condition of the propane cylinder it could be suggested that the propane leaked from the cylinder's connection or the flexible pipe connecting the cylinder and the flame tool found on the work bench in the Rope Store.

The Carpenter's Shop door could not be closed, as it had been deformed from the previous explosion in the past, thus any propane gas leaking from the cylinder connection or the flexible pipe inside the Carpenter's Shop could be easily transferred and concentrated in the adjacent spaces, such as the Rope Store and the Boatswain's Store.

Based on the extend of the damages at the area, it is concluded that the Boatswain's Store door was opened and the propane accumulated inside the lower levels of the port side of the Boatswain's Store.

The fact that propane is transparent, heavier than air and concentrates in the lower parts of an enclosed space thus it cannot be easily seen or smelled makes it difficult to be detected by anyone who does not suspect a leakage. Therefore, in the examined case the two engineers could not easily detect if any leakage from the propane cylinder or its flexible pipe had occurred. Moreover, the fact that propane vapors concentrate at the lower levels of a space, renders the ventilation of the space by natural means, such as the air ducts which existed on top of the forecastle spaces, insufficient.

Figure 18: Photos of the ventilation mushrooms placed on top of forecastle's spaces (one port and one starboard side).

4.3.2.3 Ignition source

At the time of the explosion, the two engineers were inside the forecastle, working on the repair of a pipe from the D/G. Considering that the flame tool connected to the propane and the oxygen

cylinders was found on the work bench at the starboard side of the forecastle, it could be suggested that the two engineers may had been working with the propane to repair the pipe; however this was not confirmed by the crew member who survived. Moreover, no signs of explosion or fire were found at the workbench area inside the Rope Store where the flame tool was found, thus the workbench area could be excluded from the possible areas of the ignition source.

Despite the above, the ignition of the explosive atmosphere could be attributed to an electrical spark of the electrical equipment in the forecastle area. As stated in par. 4.3.1.5, evidence of unprotected lighting electrical equipment was found. More specifically, next to the Boatswain's Store door an extension cable was found leading to an open unprotected lampholder above the door. However, no further "in situ" evidence was available due to the damages caused by the explosion's strong blast and the fire.

In light of the above, the ignition source of the explosion could not be identified. Other possible sources of ignition such as spark caused by static electricity or friction/impact of metal tools or other metallic equipment could not be excluded.

4.4 Hot works on board

As already mentioned, propane and oxygen cylinders as well as their flexible pipes were stored in the Carpenter's Shop. Moreover a welding machine with its cables and a welding protective mask were found in the forecastle area. The crew was aware of the existence of the gas cylinders in the Carpenter's Shop and during the fire extinguishing operation the cylinders were promptly removed to the open deck for safety purposes.

During the interview process it was reported that Nakhodka's crew was not allowed to use the propane cylinder and they were stored only to be used by shore repair personnel, when required. However the flame tool found on the work bench after the explosion which was connected to the propane and the oxygen cylinder, suggests that it had been used by the vessel's crew or it was about to be used by the two Engineers.

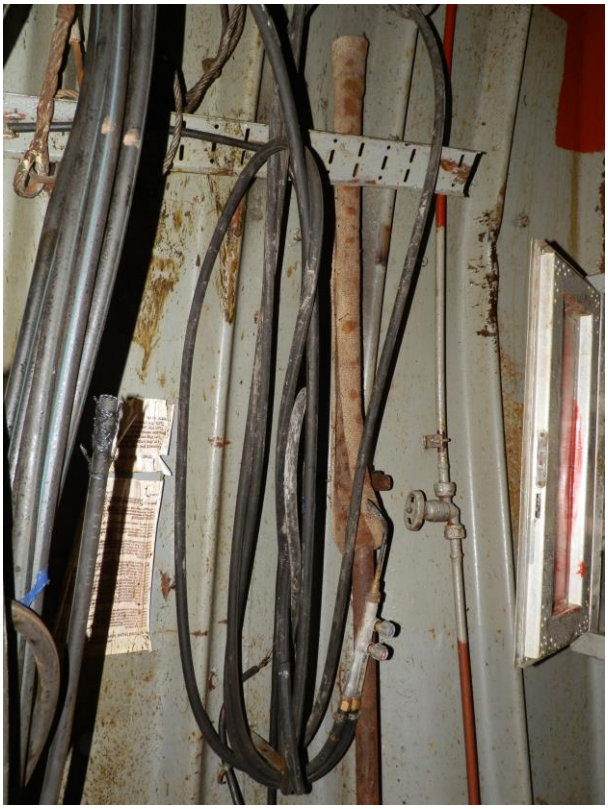

Figure 19: The flexible pipe hanging on the bulkhead of the Caprenter's Shop.

The IMO Maritime Safety Committee, at its 77th session, having considered the safety issues related with hot works on board vessels, developed a user-friendly list of common principles applicable to all hot work situations on board all type of vessels and issued MSC/Circ. 1084, 13 June 2003. The aforementioned IMO Circular, states: *"1.2 The Safety Management System (SMS) on board should include adequate guidance on control of hot work and should be robust enough to ensure compliance. Absence of guidance should be regarded as prohibition, rather than approval."*

During the interview process, it was reported that hot works by the crew were not allowed and the vessel's SMS did not include any specific guidance or procedures. Furthermore, no evidence of preventive or other precautionary measures to deter the crew members from using the propane cylinder or from performing hot works in the forecastle was found "on scene", such as warning signs or presented by the vessel's crew.

Thus, it is inferred that the vessel's management didn't incorporate any measures to ensure that the propane cylinders were not used by the vessel's crew.

4.5 Indications of past explosion

.1 During the "on scene" investigation process it was observed that the bulkhead as well as the door between the Carpenter's Shop and the internal passageway were deformed, indicating an explosion inside the room. However, there was no sign of fire inside the Carpenter's Shop, while the equipment that was stored in it was found that remained intact, suggesting that the explosion and fire of the examined marine casualty had not occurred in this compartment. The door had no lock on it and it bore signs of corrosion that were deep enough and could not be attributed to recent surface oxidation by the fire extinguishing water. Furthermore, other points, such as the doorstep, were deformed or cracked and showed a good and clean condition of their painting coat around the corroded parts. Considering the above, it is concluded that the cracks and deformations of the Carpenter's Shop door and bulkhead are not related to the examined marine casualty and considered to had been caused due to a past explosion, which occurred inside the room.

During the interviewing process, it was confirmed that there had been another incident of explosion on board, inside the Carpenter's Shop, which caused the deformation of its internal bulkhead and door. However, the exact time of the previous incident could not be specified by the interviewees; it was reported that it should had occurred more than 4 months from the date of the examined accident. It is noted that the damaged bulkhead and door had impact on the structural integrity of the Carpenter's Shop. Consequently, the "Class A division" criteria as defined in SOLAS 60, Ch. II, Part D, Reg. 35 and presented in Nakhodka's Fire control Plan, as referred in par. 4.1, was abolished.

.2 The International Safety Management Code (ISM Code – SOLAS 74), in Chapter 9 "*Reports and analysis of non-conformities, accidents and hazardous occurrences*" states:

"9.1 The SMS should include procedures ensuring that non-conformities, accidents and hazardous situations are reported to the Company, investigated and analyzed with the objective of improving safety and pollution prevention.

9.2 The Company should establish procedures for the implementation of corrective action, including measures intended to prevent recurrence."

However, during the investigation process it was not evident that the incident had been reported to the vessel's managing company or the Classification Society that issued the vessel's Class and Statutory Certificates. Based on the available documentation, the last inspection of NAKHODKA by the Classification Society was performed at Taganrog, Russia on 12 September 2013, in terms of the periodical annual survey.

In light of the above it is inferred that the respective provisions of the ISM Code had not been followed. Furthermore, it is suggested that had the proper procedures been followed for the past

explosion incident with thorough investigation and analysis, proper safeguards and safety measures could have been implemented and the examined marine casualty could had been avoided.

4.6 Storage of flammable substances

The propane and oxygen cylinders of NAKHODKA were stored in the Carpenter's Shop in the forecastle. However, the time when the cylinders were placed inside the forecastle could not be established as the information provided by the crew during the investigation was limited.

The storage of flammable materials as well as oxygen and acetylene cylinders is regulated by the Rules of the vessel's Classification Society where it is stated:

RMRS rules, Chapter VI, p.385

*"**2.1.5.3** Storerooms for flammable materials and substances shall comply with the following requirements:*

***.1** storerooms for flammable materials shall not be generally situated in common with accommodation spaces in superstructure or deckhouse. Access to the storerooms shall be provided from the open deck directly or through a corridor and/or a stairway leading only to these storerooms,*

***2.** all electrical equipment of the storeroom shall be explosion proof in compliance with 2.9, Part I " Electrical Equipment".*

***2.1.5.4** Spaces for electric and gas welding operations shall comply with the following requirements:*

***.1** the spaces shall be separated from adjacent spaces by " A-60" class divisions.*

***.2** spaces shall have direct access from the open deck, the doors shall open outwards and be fitted with locks.*

***.3** location and arrangement of such spaces in oil tankers is subject to special consideration by the Register,*

***.4** oxygen and acetylene cylinders for electric and gas welding operations shall be kept in separate storerooms, complying with the following requirements:*

***.4.1** acetylene cylinders storeroom shall be independent of the oxygen cylinder storeroom,*

***.4.2** storerooms shall not be located below accommodation spaces and control stations or be adjacent to them. Besides, storerooms shall not be adjacent to machinery spaces of category A, galleys, storerooms for flammable materials and substances, as well as to fuel oil and lubricating oil tanks,*

***.4.3** divisions separating the storerooms from adjacent spaces shall be of "A-60" class,*

***.4.4** such spaces shall have direct access from the open deck, the doors shall open outwards and be fitted with locks providing their reliable closure to prevent unauthorized access,*

***.4.5** the warning plates: "Danger of explosion!" and "No smoking!" shall be provided on the storerooms doors".*

Considering the above, it is concluded that the storage area of the oxygen and propane cylinders and the area of the work bench where hot works were carried out in the forecastle, as presented in par. 4.1 and par. 4.2.1.3 - 4.2.1.5, were not following the respective provisions of the Class Rules. Moreover, no information was provided concerning any specific instructions by the vessel's Managers particularizing proper location and appropriate procedures for the oxygen and propane cylinders storage.

It is noted that Classification Society Rules do not lay down any specific provisions for propane cylinders storage. Furthermore, according to relevant correspondence with RMRS it was clarified that the Class Rules do not contain any requirements for the use of propane gas for hot works on board and that the storage of propane or similar gases cylinders, other than oxygen/acetylene is not allowed on board their classified vessels.

Company's lack of following the Class Rules and incorporating specific procedures and guidelines in relation to flammable gas cylinder storage and use is considered to had been a contributing factor into the examined case.

4.7 Fire extinguishing

4.7.1 Fire extinguishing by the crew

The Chief Officer following the explosion sounded the alarm from the bridge and went to the bow to assess the situation. The crew members were mustered at the fore deck and deployed two fire hoses from the starboard side of the vessel, while the 2nd Engineer assisted by the Electrician started the fire pumps. The firefighting operation by the crew was launched about 10 to 15 minutes after the explosion, by spraying water from the top of the No1 cargo hold hatch cover to the port side door of the forecastle as well as to the Paint Room door. It was reported that the crew members who handled the fire hoses did not use the firefighter outfits that were stored in two lockers of the vessel. However, only one locker located at the port side of the accommodation was accessible, as the second locker was in the Carpenter's Shop.

Figure 20: The fireman's outfit stored in the fire locker at the port side of the Accommodation.

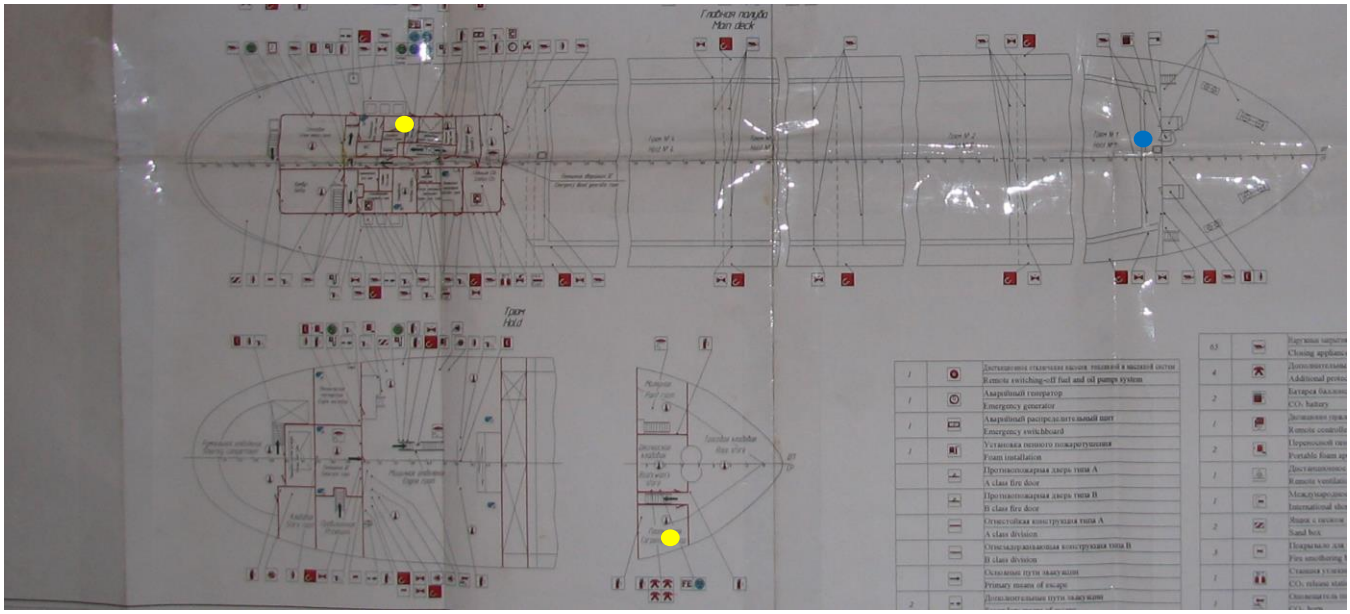

Figure 21: The locations of the Fire Lockers (yellow dots) and the location of the Paint Room fixed CO_2 firefighting system (blue dot).

4.7.2 Fixed CO_2 fire extinguishing system

Apart from the above, the Paint Room was equipped with a fixed CO_2 fire extinguishing system. The CO_2 cylinders were located at the aft bulkhead of the forecastle on the main deck close to the Paint Room door. It was reported during the interview process that the Chief Officer attempted to close the door of the Paint Room in order to release the CO_2 but he couldn't get close due to high thermal emissions and smoke that were being generated by the fire and escaping through said door.

Figure 22: The fixed CO_2 fire extinguishing system located outside of the Paint Room door.

4.7.3 Shore side fire extinguishing units

The first vehicle of the Fire Brigade arrived on scene approximately 40 minutes after the explosion and later three more vehicles arrived. The Fire Fighters took over the fire extinguishing operation and the fire was eventually extinguished, at approximately 13:30.

During the firefighting operation the Fire Brigade personnel requested crucial information from the vessel's crew concerning the arrangement of the forecastle spaces, the materials stored inside the forecastle, the cause of the fire etc. However, it was reported that the crew of NAKHODKA had difficulties communicating in English and could not provide the requested information imminently and adequately.

4.8 Burn Injuries - Protective Clothing

4.8.1 Fire or explosion hazards

Explosions or flash fires are common hazards at vessels' workplace environment, due to the presence of a variety of flammable materials, such as oils, petrochemicals, paints and solvents or even cargo with fire hazards under certain conditions. Moreover, occasionally the crew is performing hot works on board by using electrical welding machine or oxygen/acetylene tool, thus the risk of a fire or an explosion increases.

Normally, under the ISM Code provisions fire or explosion hazards should be identified and precautionary measures should be incorporated to mitigate the risk. Nonetheless, in the maritime sector fire or explosion incidents still occur, while some of them had resulted to serious injuries of crew members or to loss of life.

It is highlighted that in the 2015 EMSA's Annual Overview of Marine Casualties and Incidents[6], updated in 07/06/2016, it is recorded that for the years 2011-2014 from the total accidents and incidents reported to the European Marine Casualty Information Platform (EMCIP) by the European Member States, 152 accidents, corresponding to the 8% of the total reported accidents and incidents, were involving Fire/Explosion occurrences. For the "very serious marine casualties", Fire/Explosion is ranked as the third accidental event category with 14%, which corresponds to 25 occurrences out of a total number of 178 very serious marine casualties.

4.8.2 Fire or explosion consequences to the crew

Accidents of fire can have a major impact on crew safety as they can cause severe burns on an individual's body as well as inhale burns. If the injury is serious it cannot be treated by means of the vessel's medical first aid response supplies and equipment and immediate medical assistance and hospitalization is required. Moreover, extended burns may cause local or systematic complication that could lead to incapacitation or even life threatening injuries. The situation becomes more difficult directly threatening a crew member's life if a vessel is far away from shore assistance and any Medevac operation is not feasible, as severe burns are not to be self-treated on board and require medical attendance and hospitalization.

It is noted that in several cases of injuries after flash fires or explosions the most serious burns are not on the uncovered body parts of the injured personnel like the head or the hands. In the opposite, the most severely burned body areas are experienced under the regular working clothing. The burning clothes keep burning even after the flame has retreated, and while being in contact with the skin they cause the most severe burns.

4.8.3 Examined case's sustained injuries

In the examined marine casualty the clothing of the two engineers was burnt on their bodies and caused extended 2nd and 3rd degree burns on more than 70% of their bodies. They got out of the forecastle while their clothes were still burning and were provided first aid by the Master and the Cook. However, their health status was very serious and the vessel's crew was not able to cope with the situation as the medical supplies and equipment of the vessel and crew medical training are not sufficient for handling severe burns.

[6] http://www.emsa.europa.eu/emsa-documents/latest/item/2551-annual-overview-of-marine-casualties-and-incidents-2015.html

When they were transferred at the local hospital they were intubated and transferred to a specialized Burn Hospital in Athens on the same day, however only one of them recovered.
It was reported that during the emergency response for providing medical assistance and the hospitalization of the injured seamen, communication problems were experienced, as NAKHODKA's crew had difficulties to communicate in English. Most of the communication was carried out by gestures and body language, which somehow restricted the implementation of quick response.
In view of the above as well as par. 4.8.2, it is inferred that the common type overalls of Nakhodka's injured crew members did not protect their skin from burns, whilst it is considered that they worsened sustained burns.

4.8.4 Protective clothing against flame

At the time of the explosion, the two engineers were wearing their usual work overalls. It was reported that their overalls were the common type made with cotton as the main fabric. This type of clothing is commonly used by vessels' crews mostly for their cooling and sweat absorbing features. However, said type does not hold any fire retardant of fire resistant characteristics and consequently it does not provide any protection to the body from flash fires or explosions. On the contrary, it may cause more severe burns as already presented in the previous paragraphs. Nonetheless, the use of fire retardant or fire resistant protective clothing has not been introduced to the crews when they are performing tasks with fire or explosion hazards, or to the crews of certain capacities that usually perform such tasks, like the engineers.
Considering the aforementioned it is highly possible that had the two engineers been wearing protective clothing with fire retardant of fire resistant features, their burns could have been milder than those suffered, resulting to an increased possibility of less skin damage and full recovery.

4.8.5 Fire retardant or fire resistant clothing standards

As stated in the previous paragraph the maritime sector has not yet adopted any precautionary measures such as the use of fire retardant or fire resistant clothing by crew, when performing tasks with fire or explosion hazards, therefore this type of protective clothing is not used onboard ships. Nonetheless respective standards have been developed by certain Organizations for the workers' protective clothing against fire as presented below:

ISO 11612:2015[7]

This standard specifies performance requirements for protective clothing made from flexible materials, which are designed to protect the wearer's body, except the hands, from heat and/or flame. For protection of the wearer's head and feet, the only items of protective clothing falling within the scope of this standard are gaiters, hoods, and overboots. However, concerning hoods, requirements for visors and respiratory equipment are not given.
The performance requirements set out in this standard are applicable to protective clothing which could be worn for a wide range of end uses, where there is a need for clothing with limited flame spread properties and where the user can be exposed to radiant or convective or contact heat or to molten metal splashes.

[7] http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=57457

FLAME RETARDANT COVERALL

EN ISO 11612

- **Code A:** Limited flame spread
- **Code B:** Protection against Convective Heat-3 levels
- **Code C:** Protection against Radiant Heat - 4 levels
- **Code D:** Protection against Molten Aluminium Splash - 3 levels
- **Code E:** Protection against Molten Iron Splash - 3 levels
- **Code F:** Protection against Contact Heat Â· 3 levels

Figure 23: Indicative flame retardant overall ISO 11612:2015 (source web)

ISO 11611

ISO 11611:2015[8]

This standard specifies the minimum basic safety requirements and test methods for protective clothing including hoods, aprons, sleeves, and gaiters that are designed to protect the wearer's body including head (hoods) and feet (gaiters) and that are to be worn during welding and allied processes with comparable risks. For the protection of the wearer's head and feet, this International Standard is only applicable to hoods and gaiters. This International Standard does not cover requirements for feet, hand, face, and/or eye protectors.

This type of protective clothing is intended to protect the wearer against spatter (small splashes of molten metal), short contact time with flame, radiant heat from an electric arc used for welding and allied processes, and minimizes the possibility of electrical shock by short-term, accidental contact with live electrical conductors at voltages up to approximately 100 V d. c. in normal conditions of welding. Sweat, soiling, or other contaminants can affect the level of protection provided against short-term accidental contact with live electric conductors at these voltages.

[8] http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=57455

FLAME RETARDANT COVERALL

EN ISO 11611

- Limited Flame Spread (A 1 + A2)
- Molten Droplets
- Heat Transfer (radiation)
- Electrical resistance

Class1:protection against less hazardous welding techniques and situations, causing lower levels of spatter and radiant heat

Class2:protection against more hazardous welding techniques and situations, causing higher levels of spatter and radiant heat

Figure 24: Indicative flame retardant overall ISO 11611:2015 (source web)

BS EN ISO 14116

This standard specifies the performance requirements for the limited flame spread properties of materials, material assemblies and protective clothing in order to reduce the possibility of the clothing burning and therefore avoiding a hazard. Additional requirements for clothing are also specified.

Protective clothing complying with this standard is intended to protect workers against occasional and brief contact with small igniting flames, in circumstances where there is no significant heat hazard and without the presence of another type of heat. When protection against heat hazards is necessary in addition to protection against limited spread flammability, then standards, such as BS EN ISO 11612 , are more appropriate.

4.9 Crew of M/V NAKHODKA

M/V NAKHODKA counted a crew of 11, as per her Minimum Safe Manning Document issued by her Flag State. All crew members were of Russian nationality; with Certificates of Competence according to their grade on board and the established working language on the vessel was Russian. The SMS of NAKHODKA provided mandatory familiarization training to all crew members prior to their duties assignment, documented by respective signed check lists. Nonetheless, the relevant documentation with regard to the Chief Engineers' familiarization procedure was not presented during the investigation process, thus it was not evident that he had completed the familiarization process with the vessel's safety equipment and procedures before taking over his duties.

4.9.1 The casualties

The Chief Engineer was 38 years old and had joined NAKHODKA on the 17th of April 2014, just 9 days before the accident.

The 3rd Engineer was 24 years old and was serving on NAKHODKA since the 10th of March 2014, which corresponds to 47 days before the accident. He had completed the familiarization procedure on 17-03-2014 and signed the relevant document.

4.9.2 The rest of the crew

The Master

The Master was 51 years old and had been working as a Master on board general cargo vessels since 2006. In December 2013 he was appointed on NAKHODKA. He had also served as a 2nd Mate and Chief Mate on vessels of similar type. He had completed the familiarization procedure on 25-12-2013 and signed the relevant document.

The Chief Officer

The Chief Officer was 61 years old and he was serving for the second time on NAKHODKA. He held a Master's CoC and had been contracting with the vessel's managers since 2010. His past experience included several years as a skipper on large fishing vessels and on salvage vessels. He joined on NAKHODKA about 4 and half months before the accident. According to the relevant SMS document he had completed the familiarization procedure on 19-12-2013.

The Second Officer

The 2nd Officer had joined NAKHODKA on 18-12-2013. He was 35 years old and he had been servicing on vessels of the same type since 2005. According to the relevant SMS document he had completed the familiarization procedure on 25-12-2013.

The 2nd Engineer

The 2nd Engineer was 52 years old and joined NAKHODKA on 16-01-2014. He had also served on other vessels of the same company in the past. He had completed the familiarization procedure on 23-01-2014.

The Electrician

The Electrician, aged 64, had signed on 17-04-2014, together with the Chief Engineer and he had completed the familiarization procedure on 22-04-2014.

The AB

The AB who was on watch duty during the accident was 50 years old and was also performing Boatswain duties. He had joined NAKHODKA on 08-03-2014 for a short term contract of 3 months to replace another AB during his leave. He had served on fishing vessels and other general cargo vessels since 1983, while this was his first contract with NAKHODKA's managers.

4.10 Communication skills

According to SOLAS Chapter V, Safety of Navigation, Reg. 14.4 English language is to be used as the working language for bridge-to-bridge and bridge-to-shore safety communications as well as for communications on board between the pilot and bridge watchkeeping personnel, unless those directly involved in the communication speak a common language other than English.
Moreover, the relevant Chapters of STCW Code Part A include the use of English in written and oral form into the mandatory minimum requirements for certification of Officers in charge of a navigational or an engineering watch. In respect to the above IMO has compiled the Standard Marine Communication Phrases, widely known as the "IMO SMCP's", as adopted by IMO Res. 918 (22).

However, as recorded in par. 4.7 and 4.8.1 the crew of NAKHODKA had difficulties in speaking and understanding the English language and could not provide imminently and adequately the requested information to the Fire Brigade's personnel, which hindered the overall fire

extinguishing operation. Apart from the above, the interviews of the Master and the other crew members were carried out with the assistance of a translator, as they experienced difficulties of communicating in English with the investigation team, even for the basic standard marine communication phrases. It is noted that during the emergency response the port facility personnel experienced communication difficulties with the crew of NAKHODKA.

On the grounds of the above it is concluded that NAKHODKA Officers' communication skills in English did satisfy the respective requirements of SOLAS Chapter V/Reg.14.4 and STCW Code, Part A, Ch. II and III.

4.11 Risk assessment

The Company's SMS comprised in the SMM (items 1-10-ISM and 2-13-ISM) the risk assessment procedure, for all hazardous tasks carried out on board.

However, during the investigation process, no evidence was presented with regard to the conduct of risk assessment by the company or by the responsible crewmembers before performing hot works inside the forecastle.

It is noted that the Master and the Chief Officer were not informed for any works that were to be carried out by the two engineers on the day of the accident.

4.12 Fatigue

According to the data collected from the vessel's watchkeeping schedule and the working-resting hours records, as well as the interviewing process, no indication was evident that fatigue had contributed to the investigated marine casualty.

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.

5. Conclusions

1. The two engineers entered the forecastle spaces to repair a pipe without following any specific procedures and without informing the Master (§4.2).
2. The explosive atmosphere inside the forecastle was created by propane leakage (§4.3.2.1, §4.3.2.2).
3. The ignition source could not be identified (§4.3.2.3).
4. The vessel's SMS did not provide any specific guidance or procedures for the safe conduct of hot works on board, and it did not implement any measures to ensure that the propane cylinders are not to be used by the vessel's crew (§4.4).
5. The Carpenter's Shop had suffered a past explosion. However this occurrence was not investigated and analyzed under the relevant provisions of the ISM Code (§4.5).
6. The storage area of the propane and oxygen cylinders was not satisfying the respective Classification Society's Rules for the storage of oxygen/acetylene cylinders (§4.6).
7. The Classification Society's rules did not allow the storage of propane cylinders on board and did not comprise any specific provisions for it (§4.6).
8. The managing company did follow the Class Rules and did not provide any instructions to the vessel's crew regarding the storage of propane and oxygen cylinders (§4.6).

9. The vessel's crew did not use the fireman's outfit for the fire extinguishing operation (§4.7).
10. Explosions or flash fires are considered common hazards at vessel's workplace environment (§4.8.1).
11. In flash fire or explosion incidents regular clothing burns and causes more severe burn injuries (§4.8.2).
12. The two engineers were wearing cotton made overalls which burnt onto their bodies (§3.3, §3.5, §4.8.3, §4.8.4)
13. The common type overalls of Nakhodka's injured crew members did not protect their skin from burns, whilst it is considered that they worsened sustained burns (§4.8.3).
14. The use of fire retardant or fire resistant clothing when performing works with fire or explosion hazards has not yet been introduced in the maritime sector (§4.8.4, §4.8.5).
15. NAKHODKA's Officers could not communicate in English language as provided by SOLAS Chapter V/Reg.14.4 and STCW Code, Part A, Ch. II and III. The poor communication skills hindered the fire extinguishing efforts by the Fire Brigitte (§4.7, §4.10).
16. No risk assessment procedure had been carried out for the conduct of thermal works inside the forecastle. (§4.11)

6. Actions taken

According to information provided by the vessel's managers during the consultation period of the draft investigation report, following measures had been taken:

- Issuance of Company's Order by which the storage on the vessels of non-standard equipment and materials such as propane/oxygen cylinders and gas-welding equipment is not allowed.
- Issuance of Company's Order by which Chief Officers and Chief Engineers had been appointed and instructed as responsible for the forecastle and steering compartment respectively.
- Instructions for entering into enclosed spaces had been developed and posted on the doors. Any works in these compartments should be carried out after receiving permission from the responsible crew member.
- Internal audit was carried out according to ISM Code provisions.
- Conduct of additional firefighting drills and trainings.
- Inspection of firefighter's outfit by Company's designated person and replacement of certain parts of equipment.
- Special attention is given during the internal audits to the condition of the firefighter's outfit, Boatswain's Store, Paint Room, Steering compartment, the posted instructions at the entrances of said spaces and the duties of the crew during drills and trainings.

7. Safety recommendations

Taking into consideration the analysis and the conclusions derived from the safety investigation conducted the following recommendations are issued:

7.1 The owners/managers of NAKHODKA are recommended to:

21/2014: Establish specific measures to the company's SMS to ensure that Officers in charge of a navigational or an engineering watch are able to use the English language as provided by SOLAS Chapter V/Reg.14.4 as well as STCW Ch. II and III.

22/2014: Assess the need of acetylene/oxygen cylinder supplies on board the vessel. If such need deems necessary, set standards and procedures for the storage area in compliance to the Classification Society's Rules and Flag State's regulations, if applicable.

23/2014: Consider providing the crew with fire retardant or fire resistant clothing (overalls) for use in works or operations with fire or explosions identified hazards.

24/2014: Highlight fleet wide the hazards of storage and use of flammable gases, by means of a relevant circular or relative signs posted at the storage area of such materials.

25/2014: Investigate and analyze the past explosion incident in the Carpenter's Shop, as per ISM Code provisions.

26/2014: Implement appropriate measures to ensure that all occurrences on board are notified to the company, as per ISM Code provisions.

7.2 The Classification Society of the vessel (RMRS) is recommended to:

27/2014: Consider the necessity of addressing a circular to its classified vessels underlining the applicable rules for the storage of acetylene/oxygen cylinders and that the storage of other similar gases such as propane is not allowed on board.

7.3 The Russian and Greek Maritime Administrations are invited to:

28/2014: Consider the necessity of introducing guidelines for the use of certified fire retardant or fire resistant protective clothing on board respective flagged vessels during works with fire or explosion hazards and consider of bringing said proposal to the competent International or European Bodies, as deemed appropriate.

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Accident Investigation Report 03/2014
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