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Aircraft, Maritime and Railway Accident Investigation Directorate
Maritime Accident Investigation Unit

FINAL REPORT

INVESTIGATION OF A VERY SERIOUS MARINE CASUALTY – FIRE IN THE CREW CABINS OF MOTOR VESSEL "GEROITE NA SEVASTOPOL" AND DEATH OF A CREW MEMBER
9 March 2018

2019

FOREWORD:

Extract from the Merchant Shipping Code:

Art. 79. *(Amended, SG № 41/2001, amended, SG № 113/2002, amended, SG № 87/2005, in force since 01.01.2006., amend., SG № 92/2011, amend., SG № 93/2017)*

(1) Investigation of marine accidents and incidents shall be carried out by investigating officers in the specialized unit for investigation of marine accidents and incidents at the Ministry of Transport, Information Technology and Communications.
(2) The investigation under para. 1 aims to contribute to enhancing the safety of maritime transport and preventing marine casualties by identifying the causes and circumstances of the occurrence of a particular accident without making any conclusions about the existence of fault or liability. The investigation under par. (1) shall be carried out separately and irrespectively of the criminal administrative penal or civil proceedings conducted in respect of the same marine accident and shall not be prevented, suspended or delayed by reasons of the conduct of such proceedings.
10) Any safety investigation shall end with a report drawn up in the form and content specified in the ordinance referred to in paragraph 13. Within 12 months from the date of the marine accident or incident, the head of the specialized unit under para. 1 shall publish the report, including the conclusions and recommendations contained therein, on the website of the Ministry of Transport, Information Technology and Communications. The conclusions and recommendations contained in the report cannot be used in the course of civil, administrative or disciplinary proceedings

Note: Investigation materials should not be used in litigation and / or settlement of trade disputes, and the specialized unit, or the Ministry of Transport, Information Technology and Communications, can neither be a party to nor involved in such proceedings and disputes.The report is published on the Internet at the official website of the Ministry of Transport, Information Technology and Communications: https://www.mtitc.government.bg/.

All times used are local time (UTC+2).

Fig. 1 *m/v "GEROITE NA SEVASTOPOL"*

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USED TERMS AND ABBREVIATIONS

ASE	Apparatus for working in a smoky environment
EAMA	Executive Agency "Maritime Administration"
ECR	Engine Control Room
EEBD	Emergency Escape Breathing Device
IMO	International Maritime Organization
ISM Code	International Safety Management Code
MSC	Marine Safety Committee
Muster station	The location on a vessel a person goes during an emergency or a muster drill.
P&I Club	Protection & Indemnity Club – ship owners' association for mutual protection and indemnity
SMS	Safety management system
SOLAS	International Convention for the Safety of Life at Sea
STCW	International Convention on Standards of Training, Certification and Watch keeping for Seafarers

SUMMARY:

At about 1330 on 9 March 2018, a fire broke out on the first deck of m/v "GEROITE NA SEVASTOPOL"'s superstructure while the ship was en route from Chernomorsk, Ukraine to Poti, Georgia. The place of fire was localized in the messmen' cabin. The fire spread rapidly in the adjacent cabins and in the corridor of the same deck, filling them with a heavy smoke. At 1332 the ship's "General alarm" sounded and the crew gathered at the "Muster station" to fight the fire.

A check for availability of the crewmembers revealed the absence of the ship's cook and one of the messmen. A reconnaissance group equipped with ASE was sent to bring the cook from his cabin to a safe place. They did not manage to enter the messmen' cabin, due to the high temperature and the heavy smoke. At 1405 the fire was under control and the missing messman was found dead in his cabin. At 1410 the fire was finally extinguished.

The Specialized Investigation Unit for Marine Accidents classified the accident as a "Very Serious Casualty"[1]. The investigation of the accident was carried out by a Commission consisted of inspectors from the Specialized Unit.

As a result of the investigation, the Commission came to the following conclusions:

- The fire on the ship has occurred due to hot works carried out on the outside of the messmen's cabin.

- The main cause leading to the very serious accident - fire and death of a crewmember was the failure to provide a fire safety surveillance during hot works on the inside/back of the messmen cabin partition.

The Commission found that after the accident, the operator of m/v "GEROITE NA SEVASTOPOL" - Navigation Maritime Bulgare has carried out a detailed analysis of the reasons and has undertaken the necessary measures to prevent it from happening in the future.

In view of the actions taken by the operator to prevent such accidents, no safety recommendations have been made.

[1] In accordance with the definition given in IMO Code for the Investigation of Marine accidents and incidents, transposed in Ordinance № 23 on Reporting and Investigating Accidents in Maritime Spaces from 24.10.2011, in § 1, item 6 of the Additional Provisions: "Very serious casualty is a ship accident resulting in its total loss, loss of life or heavy pollution."

1. FACTUAL INFORMATION.

1.1. INFORMATION ABOUT THE VESSEL, VOYAGE AND MARITIME CASUALTY

SHIP PARTICULARS	
Name	GEROITE NA SEVASTOPOL
Flag/nationality	Bulgaria
IMO №	7529966
Call Sign	LZEB
MMSI	207008000
Registered owner	Bulgarian Marine Qualification Center
Port of registration	Varna
Operator	Navigation Maritime Bulgare JSC
Classification society	Bulgarian Register of Shipping
Type	Ro-Ro Cargo / Rail Vehicles Carrier
Date of construction	1978
Shipyard	A/S Framnaes M.V., Sandefjord, Norway.
Gross tonnage	19 518 t
Length overall	185.44 m
Beam	26.00 m
Deadweight	13 088 t
Main engine	2 x B&W 10K45GF – 12 944 kW max.

VOYAGE PARTICULARS	
Ports of call	Chernomorsk, Ukraine 07.03.2018 г. Varna, Bulgaria 03-05.03.2018 г. Poti, Georgia 27-28.02.2018 г.
Port of departure	Chernomorsk, Ukraine
Destination	Poti, Georgia
Type of voyage	International, race № 685
Cargo information	29 laden wagons, 4 empty wagons, 59 trucks
Crew	27 persons, Bulgarian citizens
Passengers	0
Other persons on board	51 - serving loading technics
Working language	Bulgarian

MARITIME CASULATY INFORMATION	
Date and time	09.03.2018 / 13:30 LT
Type of marine casualty	Very serious marine casualty – fire on superstructure first deck which has led to the death of a crew member
Position and location	43°40' N; 039°07' E / Black sea, East area
Weather conditoins	Good visibility – 5-25 nm, during the day, wind- NW 1 BN, waves - 3 BN, clouds - clear
Place on board	Superstructure first deck, s/b
Injuries/fatalities	1 messman died
Ship damage	Destroyed by fire 2 cabins, other 2 cabins repairable, burnt cables, wainscoting and more in the passageway of superstructure first deck s/b.
Cargo damage	none
Consequences for the Environment	none

1.2. GENERAL INFORMATION ABOUT THE VESSEL, SHIP OWNER AND THE OPERATOR.

The ship "GEROITE NA SEVASTOPOL" is the same type as "GEROITE NA ODESA". They were built in 1978 in Norwegian Shipyard A/S Framnaes M.V., Sandefjord. Both ships are specially designed mainly for the transport of railway wagons as well as freight trucks, containers and general cargoes. The ship can accommodate 108 freight wagons / 920 vehicles / or 100 trucks up to 16 m in length. For this purpose, the ship is equipped with a special cargo lift with a capacity of 2 wagons and driven by hydraulics.

The Owner of the two ships - "GEROITE NA SEVASTOPOL" and "GEROITE NA ODESA" since 2008 has been the state-owned company "Bulgarian Maritime Qualification Center" /BMQC/. BMQC is a national maritime training center, an independent trading company for postgraduate training and training of water transport specialists. The Center is accredited by EAMA to conduct all training courses for sea staff required by the STCW Convention. In addition to both ferries, BMQC's assets include the "Kaliakra" training sailing ship. The Quality Management System at the Center has been certified by QA Lloyd Register for a compliance with ISO 9001: 2000 and subsequently with its current version of 2015.

The Operator of "GEROITE NA SEVASTOPOL" and "GEROITE NA ODESA" (under the conditions of the bareboat charter) is "Navigation Maritime Bulgare" JSC /The Navigation/. The Navigation is the successor of a shipping company, founded in 1892, which until 2008 is the largest Bulgarian state-owned ship owner with more than one-century tradition and experience in the shipping industry.

The Navigation has an established, implemented and constantly updated Safety, Environmental and Quality Management System, as required by the International Management Code for the Safe Operation of Ships and Pollution Prevention (ISM Code), of the International Standard ISO 9001 for Quality Management Systems and those of the International Standard ISO 14001 for Environmental Management Systems as well as a security Management System in respect of the requirements of the International Ship and Port Facility Security Code (ISPS Code). The Company and its ships are checked for compliance with the ISM Code, ISPS Code, ISO 9001 and ISO 14001 standards by EAMA and RINA.

Fig. 2

"GEROITE NA SEVASTOPOL" and "GEROITE NA ODESA" serve the regular lines:

- Varna - Chernomorsk - Varna;
- Varna - Poti / Batumi - Varna;
- Chernomorsk - Poti / Batumi -Chernomorsk **(Fig. 2)**

1.3. MANNING.

By design, "GEROITE NA SEVASTOPOL" was estimated to be served by a crew of 45-members and to accommodate up to 12 passengers in 6 double cabins. Subsequently, the crew was reduced. The "Minimum Safe Manning Document" issued by Varna Maritime Administration Directorate on 12.09.2013 confirms safe operation of the ship with a minimum crew of 20 people. During the voyage from Chernomorsk to Poti, the ship has had a crew of 27 people.

Crew-released cabins were used to accommodate drivers accompanying freight cars, the number of which has increased due to reduced rail traffic. In 2011, the "Maritime Administration" Directorate - Varna issued to the ship a certificate of exclusion/exemption from SOLAS General Rules, according to which a maximum of 92 persons could stay on board. This includes crewmembers, up to 12 passengers and "other" persons whose presence is related to the operation (drivers of vehicles or other technical personnel). The ship was equipped with extra lifeboats for 32 people on both boards, as well as an additional 32 hydrothermal suits.

1.4. SHIP'S SAFETY MANAGEMENT SYSTEM.

With Resolution IMO Res. 741(18) of the International Maritime Organization, the ISM Code becomes a part of Chapter IX of SOLAS Convention. In accordance with the requirements of this Code, ships must have a system in place to be operated safely and to prevent environmental pollution (SMS). It should contain various procedures related to safety, including to hot works. Since July1998, ISM Code has come into force for passenger ships, tankers and high-speed crafts, and since July 2002, it has come into force for all other ships.

In letter MSC/Circ 1084 from 13.06.2003 (Hot works Principles), IMO Maritime Safety Committee described in an annex the general principles to be considered when designing SMS procedures or to include them in the already developed ones. These principles must be respected when planning to carry out hot works on board the ship. Some of these principles are:

"*2.6 The work area should be carefully prepared and isolated before hot work commences.*

2.7 Fire safety precautions should be reviewed, including fire equipment preparations, setting a fire watch in adjacent compartments and areas, and fire-extinguishing measures.

2.8 Isolation of the work area and fire precautions should be continued until the risk of fire no longer exists."

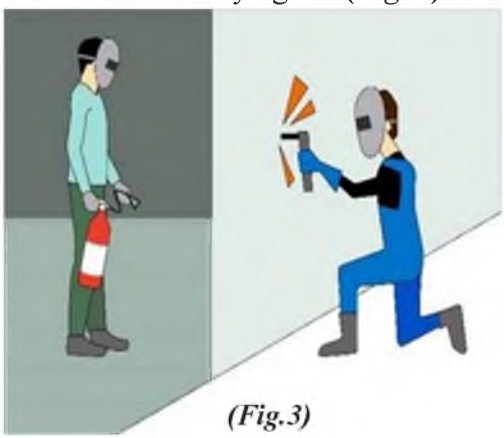
In addition to the above, the P&I Club Association issued own recommendations to ship owners for hot works, some of which are as follows:

"*Check neighboring or connected areas (such as other side of bulkhead) or internal areas (such as inside a tank) that may be heat affected to make sure they are free from flammables and combustibles*

Maintain a dedicated fire watch for both the immediate area and any potentially affected neighboring/ connected areas throughout the full operation"

The Navigation has an established, implemented and constantly updated Safety, Environmental and Quality Management System, as required by the International Management Code for the Safe Operation of Ships and Pollution Prevention (ISM Code), of the International Standard ISO 9001 for Quality Management Systems and those of the International Standard ISO 14001 for Environmental Management Systems as well as a security Management System in respect of the requirements of the International Ship and Port Facility Security Code (ISPS Code). They are subject of annual inspection and verification by EAMA and RINA, as well as of ship's time periods required by the Codes. The Navigation NMB 02/2/012 "Fire Prevention" procedure sets out rules and measures to prevent fires on board. In section 5 "Process Description", item 5.6 describes the order and requirements for carrying out hot works. The procedure has two applications: № 1 - "Fire Prevention in Machinery Spaces of Ships in Service" IMO, MSC/ Circ.601, 29.01.93, ANNEX 2 Guidance to Owners, and № 2 -"Hot works Diary", requiring the use of the following forms and diary: (FR-02-021) "Hot works Act" and "Hot works Log". An Instruction WI-02-003/2013 is issued to the procedure. It regulates the organization of fire protection measures and protection for all ships of the Navigation. The Navigation shall carry out an annual risk assessment with regard to hot works (FR-02-100) according to NMB 02/3/000 and prescribe risk mitigation measures. In general, procedure NMB 02/2/012 and instruction WI-02-003/2013 requires and provides the necessary fire safety measures for hot works.

At the same time, it can be noted that the recommendations on general principles under MSC/Circ. 1084 are not entered in full volume. For example, paragraph 2.7 of MSC/Circ. 1084 recommends fire surveillance to be carried out in the adjacent rooms and areas to those in which hot works are carrying out **(Fig. 3).** Such a requirement is not stated in NMB 02/2/012 procedure, as well as in instruction WI-02-003/2013. The presence of fire surveillance in the adjacent premises during hot works**(Fig.3)** would give a possibility to prevent such incidents.



(Fig.3)

1.5 VESSEL FIRE DETECTION SYSTEM.

The fire alarm system was installed in 1978 when the ship was built. It is a linear type system and consists of 17 separate lines, with fire detectors connected in series, of which 140 pcs. thermal type SW-1/65 and 135 pcs. smoke type NID38, as well as manual alarm push buttons located in separate premises, decks and engine room compartment. The different lines of the fire alarm system correspond to different areas of the ship in which the sensors are grouped. All lines are connected to the Fire Control Station, which is located on the bridge. When a sensor or a manual alarm push button is triggered, light and sound signaling on the Control Station the fire. There is no indication to show the exact location of the fire.

Smoke sensors are mounted on the three cargo decks and the engine room compartment. In the superstructure of the ship, where the residential rooms for the crew and the passengers are located, no smoke, but only thermal sensors are provided.

On the first bridge deck **(Fig. 4)** there are two lines of the fire alarm system - line A5 for the starboard side cabins and corridor and line B1 for the port side cabins and corridor.

Checks on the performance of the components of the fire alarm system are performed regularly. Checks on the thermal sensors indicate that they've triggered at 75 °C instead of 65 °C, as stated in the technical documentation.

Fig. 4 1st bridge deck fire plan

1.6 SEAMEN/MESSMEN' CABIN.

The seamen/messmen' cabin is located on the starboard first bridge deck **(Fig.5, Fig.6).**

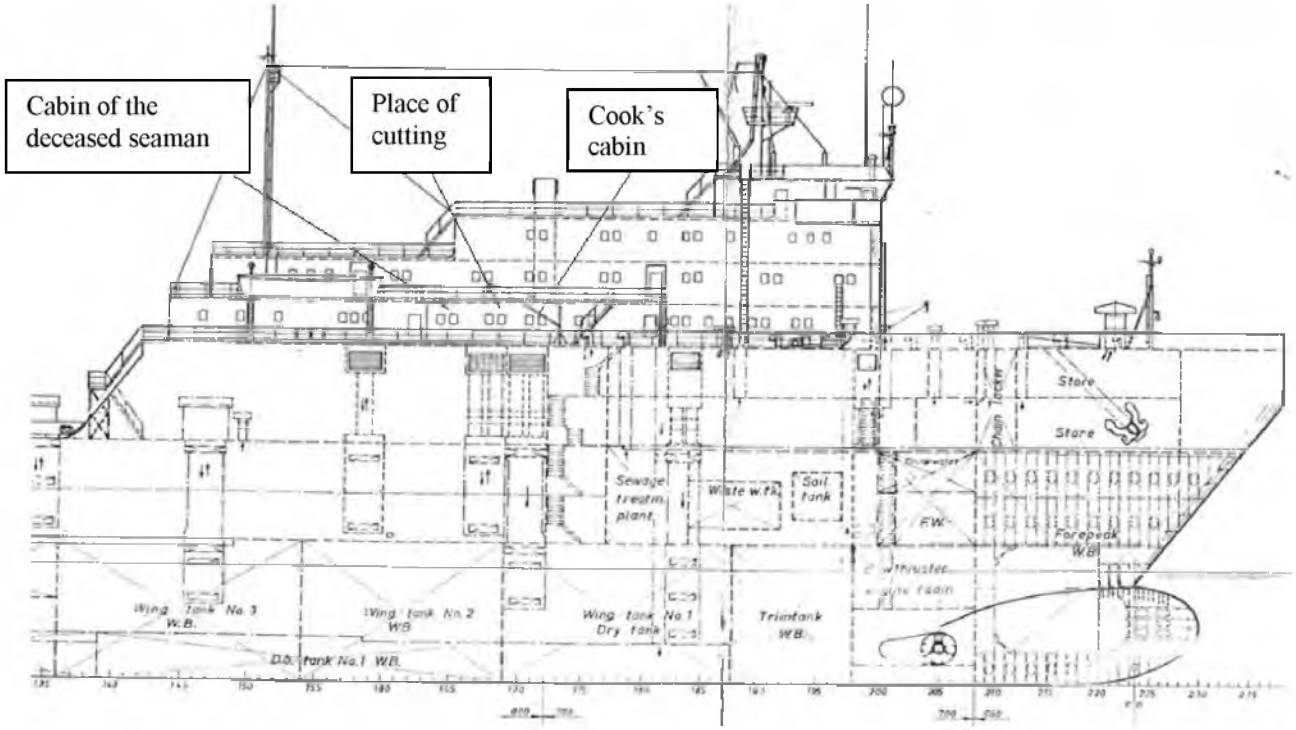


Fig. 5

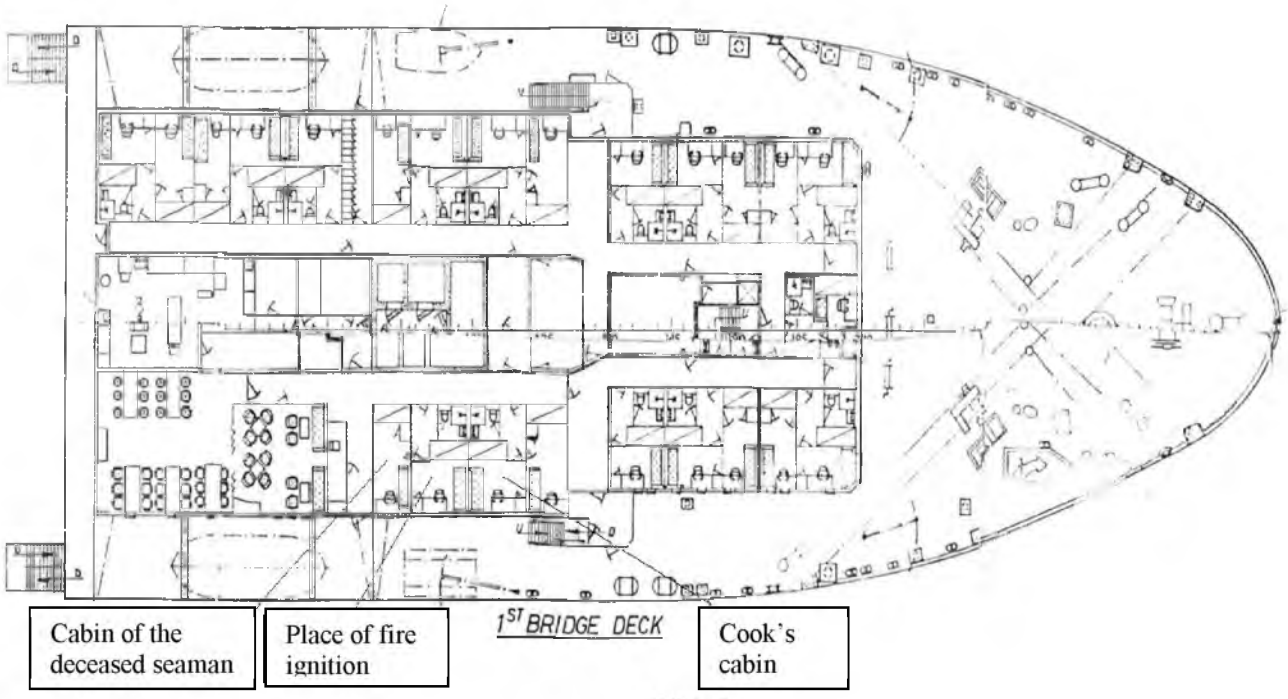


Fig. 6

The cabin has a common entrance, an antechamber and a bathroom, two bedrooms for the two seamen-messmens **(Fig. 7).** Conditionally, these rooms may be designated as room №1 (to the nose) and № 2(to the stern). The fire has arisen and has spread from Room № 1, which has been empty at this moment. Room № 2 was the deceased seaman's one, and its entrance door was located at the right of the antechamber. Room № 1 has had a heat sensor mounted on A5 line of the ship's fire alarm system.

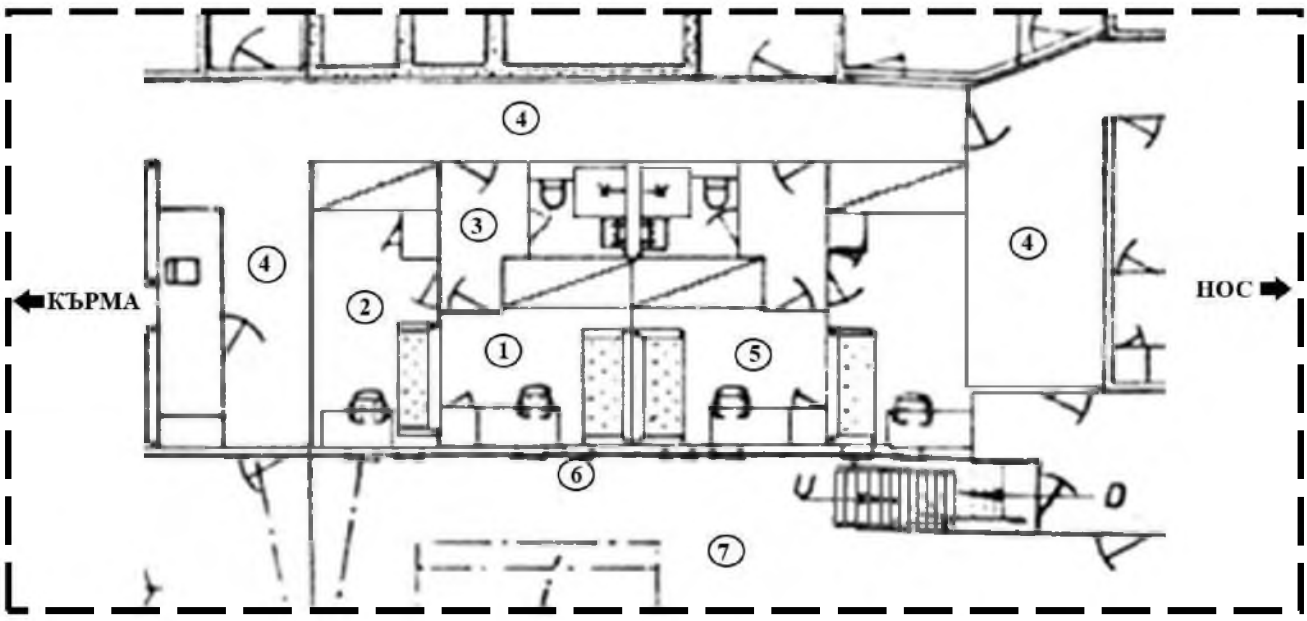


Fig. 7 A part of the cabin plan on the first bridge deck s/b side
1,2,3 - Cabin of the seamen/messmen / 1 and 2 - Bedrooms, 3 - Antechamber; 4 - Corridor; 5 – Cook's cabin; 6 - Place of hot works; 7 - Deck.

1.7 INFORMATION ABOUT THE DECEASED MESSMAN.

The deceased seaman, a 56 years old Bulgarian citizen, has been on the ship for 1 year and 7 months, with a total sea practice of more than 10 years. He has held the necessary certificates of competency and qualifications as well as a medical certificate for the performance of the position obligations.

His duties as a messman have included maintaining the hygiene of the common spaces - salons and messrooms, as well as serving and cleaning the crew's messroom.

On the day of the incident, until about 1300 he has worked in the messroom, after which, according to the work schedule, he has used a break. During the fire, he has rested in his cabin.

2. DESCRIPTION.

2.1. EVENTS UP TO THE START OF THE FIRE.

2.1.1. THE VOYAGE.

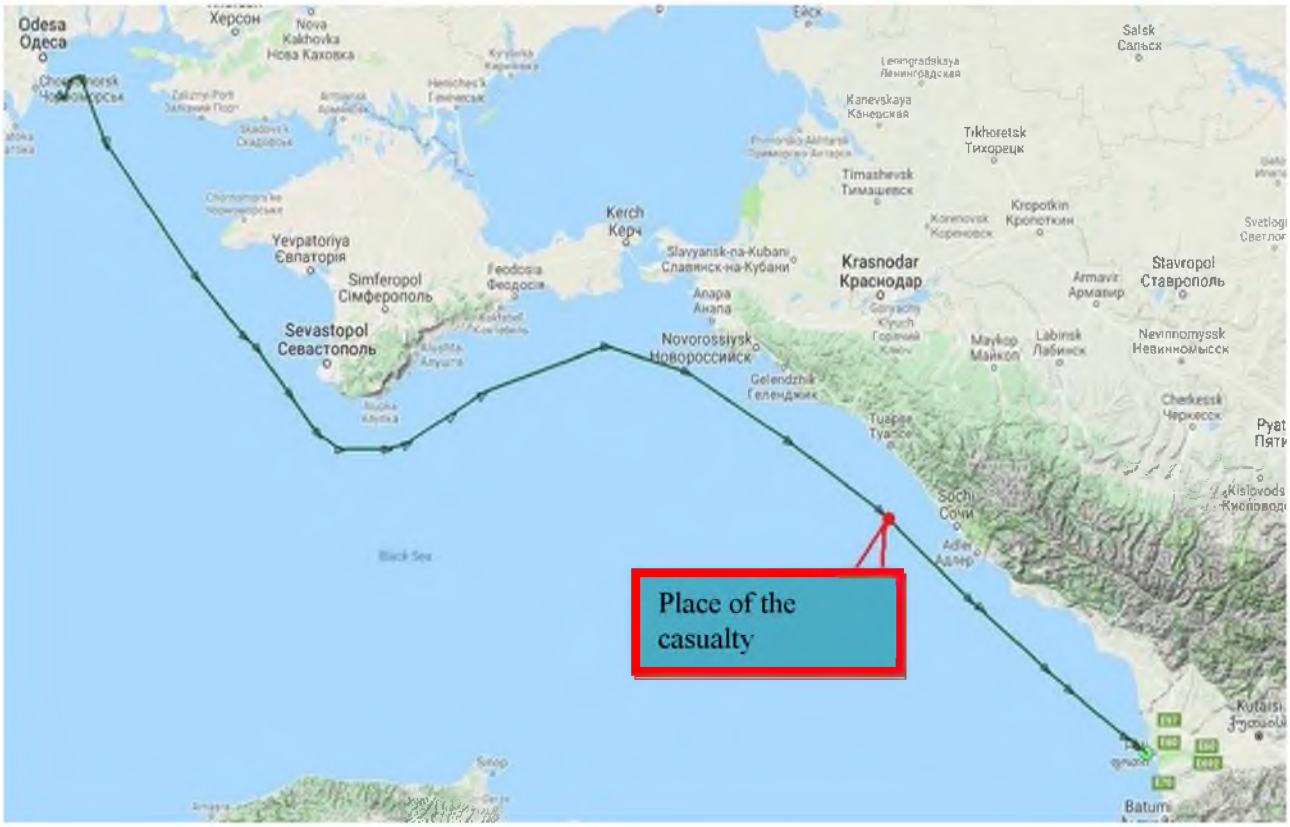


Fig. 8 Route of the ship through *marinetraffic.com*

On 9 March 2018, at about 1945, the ship sailed from the port of Chernomorsk, Ukraine, with a course to Poti, Georgia. The voyage takes approximately 2 days and a half **(Fig. 8).**

The cargo was 33 railway wagons (29 laden and 4 empty) and 59 TIR trucks. In addition to the crew, on the ship also has traveled 51 persons servicing trucks (truck drivers), citizens of Ukraine, Azerbaijan and Georgia.

2.1.2. REPAIR OF EXTERIOR LIGHTING ON THE FIRST DECK.

In the morning of 9 March 2018, during the voyage, the chief engineer has performed a work-day distribution to the Engine department. The el. engineer and the fitter have been tasked to change lamps and to repair the exterior lighting of the superstructure. The chief engineer has had to instruct both of them on safety measures at work, paying particular attention to the fire safety during hot works. The second engineer has been appointed to control the repair works. An act of hot works № 611/09.03.2018, signed by all participants and chief engineer, has been prepared. The act had been issued by the master. Upon receipt of the assignment, until lunch time at 1200, the el. engineer and the fitter have prepared the tools and materials needed for repair and have begun replacing the lights on the first deck.

Fig. 9 Starboard side superstructure

At 1300 the work has continued with replacing the lighting fixtures' lamps above the opening side scuttle of the messmen' cabin, on the starboard first bridge deck, **(Fig. 9).** First has been replaced the lamp of the lighting fixture above the scuttle of sleeping room № 2 occupied by the deceased sailor. Both metal straps attaching the lighting fixture to the board have been in a good condition, so they've been just knocked out of the rust and paint and primed for subsequent painting. The el. engineer and the fitter have stepped into replacing the lamp of the lighting fixture over the scuttle of room № 1. The packing of a new lighting fixture has been taken about 15 minutes to the el. engineer, and then the dismantling of the old one has begun. When dismantling the lamp, one of the metal straps has been disengaged from the superstructure board. This has necessitated the removal of the second strap and welding two new ones.

The fitter has blown the paint from the remaining plate, preparing it for cropping. The opening side scuttle underneath the lighting fixture has been checked to prevent sparks from cutting to enter

the room. The opening side scuttle has been tightly closed from inside. The hangings have been pulled back, closing the visibility in the room. The fitter's jumped on the second deck above the messmen' cabin and by an electric welding for about 30 seconds has cut the strap while the el. engineer from the first deck has been looking out for the fire safety.

2.2. FIRE ASCERTAINMENT.

After cutting the strap /cutting length about 3-4 cm/, the fitter's descended to the first deck and entered the superstructure to check the fire safety condition in the messmen' cabin of which outside the repairs have been done. Upon opening the antechamber door to the cabin, he's found out that from the ceiling to the middle, the room has been filled with smoke. The fitter then has opened the front door /Room №1/ and after seeing that the room's been filled with thick black smoke, he has run into the corridor and activated the hand fire alarm button. The 5th fire alarm line on the ship for a fire on the s/b first deck of the superstructure has been triggered. In his panic, the fitter's left both doors of the burning cabin open, allowing the access of oxygen in the room and the spread of the fire in the corridor. After the fire detector's been triggered, the fitter's informed the el. engineer and told him to turn off the power supply and then has attempted to connect to the bridge via the phone from his cabin. As the line had been busy, he's called the ECR unit to start up the fire pump and to notify the bridge about the fire. Then he's returned to the place of repair works, taken the fire extinguisher (prepared in advance for hot works) and has tried again to enter the cabin of the messmen. He's managed to get to the cabin antechamber, but due to the heavy smoke, entering the rooms 1 and 2 and using of a fire extinguisher there has been impossible. Meanwhile, the smoke in the rest of the superstructure has started to flow through the central ventilation ducts for hot and cold air.

2.3. CREW ACTIONS TO CONTROL THE FIRE.

At 1330 the captain has been summoned to the bridge and has taken the command. He's sent the watch keeping officer to investigate the cause of the fire alarm.

At 1332 a General Alarm signal has been switched on, followed by a fire alert message on ship's communication system. The crew's gathered at Muster Station, according to the fire-fighting schedule. The fire's spread rapidly, resulting in a heavy smothering in the corridor on the same deck. It's been practically impossible to move in it without a breathing apparatus.

At 1334 the ventilation and power supply of the entire ship superstructure's been switched off. The fire center has been located - the cabin of the messmen on the s/b side first bridge deck. The captain's ordered a change in the course of the ship to move the s/b side to the leeward side.

At 1335 the crew has begun fighting the fire, floating from the outside the cabins with water (the cook's cabin and the messmen' cabins). In addition, an inspection of the crew members and drivers gathered at Muster Station has been carried out.

At 1337 the chief officer has reported that:

- all persons accompanying the trucks have been present;
- 2 crewmembers missing - the cook and one of the messmen.

With the command of the master, a reconnaissance group has been sent to the burning cabins. The second mate, equipped with a firefighter equipment and an ASE, has attempted several times to penetrate the cabin through the stern door of the s/b side corridor, but due to the high temperature and heavy smoke has failed.

The deck bosun and one of the helmsmen equipped with an ASE have penetrated the superstructure through the bow door in the port side corridor. They have seen the cook in front of the door of his cabin, adjacent to the burning, and have pulled him back as passage through the smoky corridor without an ASE has been impossible. The cook has been brought to the deck through the opening scuttle of the adjacent cabin dividing a common antechamber with his. The bosun and the

helmsman have tried to reach the cabin of the messmen, but this has been impossible because of the high temperature and the very heavy smoke. They have returned to the cook's cabin where they've started to flood the wall of the adjacent burning cabin.

At 1339 the opening scuttle of the fired rooms №1 and №2 have been broken and their direct pouring with water has begun.

At 1340 a second line of extinguishing has started up.

At 1345 the master's received a report that all passengers have been present and unharmed. A third fire line's begun to pour the cabins from the upper 2nd deck, to prevent the fire from spreading.

At 1400 the fire has been controlled, but access to the messmen' cabin has been still not possible due to high temperature and smoke.

At 1405 the crew's managed to penetrate into the cabin, finding the lifeless body of the messman, in men's slips, fallen on the desk.

At 1410 the fire has been finally suppressed.

2.4. FINDINGS AFTER SCENE INSPECTION.

After the inspection of site scene, based on the analysis of the fire traces and the nature of the damages, as well as the mechanism of fire spreading, the initial fire center has been established - the area enclosed in the attics space above room № 1. It is important to note that on the outside and at the same time repair works have been carried out, accompanied by hot works. The room at this time has been empty, with closed opening side scuttle and pulled curtains, which has allowed the fire to spread unobstructed and unnoticed from top to bottom, covering the wainscoting and the furniture, and the smoke's formed to penetrate through the ventilation and unhermetical doors in the adjacent sleeping room № 2 where the deceased messman has been resting.

No electrical short circuit or self-ignition of electric consumers has been detected in electrical installations and electrical appliances in the cabin, which could cause fire. No evidence of intentional arson has been found also.

The posture in which the body of the deceased seaman has been found in room № 2 has given reasons to assume that he has been asleep at the time of the fire beginning in the adjacent room, awoken, probably by the fire alarm bells, and got up. Breathing the smoke in the room he had lost consciousness and fallen on the desk. This assumption has been also confirmed by forensic expertise, which has found CO content in the blood - 35% (*CO - carbon oxide, a highly toxic gas released from incomplete combustion of carbonaceous material*). The subsequent death of the sailor has occurred due to the burning I-II degree of about 75% of the body surface, the thermal shock that has occurred, the depletion of oxygen in the enclosed space (the ship's cabin), and poisoning with the fire gases - carbon monoxide, cyanide and the like.

2.5. CONSEQUENCES FOR THE SHIP.

As a result of the fire, 2 cabins have burned out. Partial repair has been required for 2 other cabins, as well as the superstructure corridor**. (Fig. 10,11,12)**

Fig.10 View from the antechamber to the messmen' cabin.

Fig. 11 1st s/b side deck corridor

Fig. 12 Cook's cabin

3.ANALYSIS.

3.1. CAUSE OF FIRE ON BOARD THE SHIP.

There are different methods for investigating fires and the reasons for their occurrence. The purpose of a fire investigation is to identify, and analyze the traces of the fire. Based on this, conclusions are drawn about the products that have been burned, the fire center, the cause of the fire and the fire spread. These traces depend on the fire/heat dynamics, type of flame, flue gas movement, etc.), ways of heat transfer (convection, conductivity, radiation, etc.). Practice shows that some of the most common sources of ignition are:

- Short circuit or high wire temperature due to overloading of the power line;
- heat impact of different heating appliances;
- heat impact of chemical reactions of technical equipment;
- open flame impact from different sources;
- self-ignition of substances and materials (including smartphone or laptop), etc. Ignition sources (IS) are generally classified according to certain characteristics:
- according to their size - they are small and large;
- by impact - spot and local;
- according to the way of impact and power they are fast-acting, short-time acting, with intermittent and prolonged action.

According to Megorsky qualification for the signs of the direction and spread of the burning, the damage and the combustion traces are determined not only by time but also by the distribution of the burning load. The fire center detection system/pointer theory/claims that the fire fades from the center to the periphery. In such cases the location of the center is determined not only by the damage but also by the signs of the combustion spread direction. They can be located over the entire area of the fire and can take the form of consistent damping damages and traces.

The formation of signs of the combustion spread direction is determined by the time factor. At the remote areas from the fire center, burning occurred later and there are less damages there. Thus, by the change of the combustible components cross-section in the fire zone, can be determined the direction where the combustion has originated and from where the fire has spread over the entire affected area. During the inspection periodically recurring defects and burning traces are established, which are consistently attenuating regardless the distribution of the burning load.

By the method of comparison, observing the degree and characteristics of the breakdowns in particular plots, it is possible to make a reasonable conclusion about the fire center taking into account:

- the consequences of the fire;
- the conditions and specificities of combustion of each section separately and in aggregate;
- direct and indirect signs of the fire center. The common signs of the development of the fire are defined into three distinct zones:
- a combustion zone
- a heat impact zone
- smoke zone

In case of adverse gas exchange, the fire originally has developed and diffused at the expense of oxygen in the air contained in the volume of the attics space. This volume has been filled with incomplete and total combustion products and the further diffuse of the fire on the combustion load has terminated. Further, combustion has continued at the expense of oxygen from the air, which has infiltrated through different ceiling gaps.

Such a nature of fire evolution has been the reason for the most characteristic signs formation in the fire center to which it has related:

- a complete combustion of solid combustible materials;
- a deep burning, carbonization of wooden elements insulation PVC melts, etc.;
- temperature deformations of metal elements.

In the messmen' cabin the walls and ceiling have been wainscoted with hard combustible/non-combustible materials. For external decorative effect they have been covered with a thin layer of wood composite material - technical veneer.

During the surveys it's been found that the panels of the walls in room №1**(Fig. 13)** has remained almost whole, with burned wood cover partially covered with coating (carbon). Above the same opening side scuttle on the outside of the cabin, the repair works have been carried out using an electric welding **(Fig. 14).**

Fig. 13 Room №1 in messmen' cabin

Fig. 14 Outside of messmen' cabin room №1

It can be noticed that the degree of deposition of the carbon coating decreases aside, and in the opening scuttle area they are almost white - without coating. The coating remains till temperatures in the range of 600–630 °C. White spots that are observed in the burning area show where the temperatures have been higher than the critical for such coatings – 630 °C. At the same time, coating of carbon particles are observed on vertical and horizontal plates in the corridor and adjacent cabins **(Fig. 15).**

Fig. 15 Damages caused by fire in room № 2

For an initial center of fire, one can define the area locked in the ceiling space above room № 1.

The temperature of the electric arc during welding develops in the range of 5 000 - 7 000 °C. The steel begins to melt/burn/ at temperatures about 1 000 – 1 100 °C. Such temperature has been developed when the lighting fixture strap was cut/blown. It is clear that the paint is completely burnt in this area (Fig. 11). Most commonly used on ships are the organic solvent based paints: alkyd and nitrocellulose paints and varnishes. Varnish coatings are a combination of film-forming substances, pigment, filler, solvent. When the paint coating is heated, the organic ingredients are subjected to thermal destruction. Outwardly, this manifests itself as a darkening. Then a carbonation occurs at a temperature of 200-400 °C. The carbon residue formed during carbonation starts a combustion process at 400° C. At temperatures above 500° C, this process is practically complete, i.e., the paint burns completely. *Therefore, it can be assumed that a local, point source of heat (ignition) with a high temperature (800 – 1 000 °C) in the area of the lighting fixture has arisen during the operation with the electric welding (about 30 seconds). Although short-acting, with a steel cabin thickness of 5 to 6 mm this temperature has transmitted relatively quickly to the interior of the cabin. It is important to note that the level/height/ of the suspended ceiling almost has coincided with the place of the hot works. The ceiling has been composed of similar to the vertical panels of the walls boards.*

Wood / wood composite material/fire damage occurs as a result of thermal and decomposition under the influence of high temperatures. In this way gaseous combustion products of thermal decomposition are released which, when reaching a certain concentration in the air, ignite and cause flame burning over the surface of the wood. The first signs of thermal decomposition of the wood (surface darkening) occur at a temperature of 110 °C. The self-heating of the wood begins at a temperature of 130-150 °C, with long heating of the wood it can pass into the so-called "pyrophorous" state and ignite at a temperature of 90 - 110° C. The active wood smolder starts at 300 °C; self-ignition of the wood occurs at about 400° C. The mechanism of occurrence and spread of internal fires during the first 10-15 minutes develops at a low speed, as the combustion happens with an average volume temperature of about 250-300 °C. At the end of this period, the linear rate of fire development is increased, and the temperature rises to 800 -1 000 °C. The mechanism of fire propagation at the initial moment is gaining area and subsequently develops at the expense of the thermal gradient.

With the detection of the fire center, the spreading of combustion of materials, the direction and degree of their carbonization give reason to determine the direction and manner of fire spreading - namely from top to down.

From the analysis of the circumstances of the damages and the fire traces, the mechanism of combustion diffusion, the initial center of the fire, it can be concluded **that the cause of the fire has been the sudden increase of the temperature in the space above the suspended ceiling of seaman-messmans' cabin room №1 as a result of hot works.**

After the in situ inspection in the messmen' cabin, the characteristic residues of primary short-circuits haven't been detected. The burnt insulators of cables and cables have been only as a result of the high temperature developed during the fire. In support of the above has come the fact that the plug of the refrigerator located in the room has been found on the floor, not melted and not plugged into the coupler.

In the testimony of one of the messmen, it's been stated that his laptop and smartphone had been plugged for charging via a triple power strip in the grid. They had been placed on the table in the room № 1, underneath the opening side scuttle, above which the hot works have taken place from the outside.

In practice, cases of self-ignition/self-explosion/ of smartphone or laptop batteries are known. The analysis of the remains reveals that the cause is in most cases that no original chargers or batteries were used. In this case, no remains of these devices have been detected. Based on the localized initial center of fire - the submerged space of the messmen' cabin, and the fire spreading, the commission's rejected the possibility that the fire could has been caused by a self-ignition of a laptop or a telephone battery.

3.2. HUMAN FACTOR ANALYSIS.

For the sake of appearance, lighting fixture repair providers have complied with the requirements of occupational safety and security, in accordance with the Ship Safety Management System (SMS) - NMB procedure 02/2/012. This procedure describes the measures to be taken to prevent fires on board. Initial and periodic instructions of the persons were carried out, depending on the position they occupy. An act on hot works has been drawn up, indicating the place of work, the manager and the measures to be taken to ensure the fire safety.

Prior to the start of the hot works, a check has been carried out and a fire safety observation has been provided, but only on the outside of the cabin wall above the opening scuttle of which they have operated. By working with the electrical welding, the fitter should have predicted that the metal on the wall, as a good conductor of heat, would heat up to a high, almost the same temperature and on the side of the messmen' cabin room № 1.

No check for the presence of fire-hazardous materials on the inside of the partition (Room 1) before the start of the hot works and no monitoring there during work has been done.

The use of an electric welding for removing the strap has not been mandatory. Such operation, with the minimum risk of fire, could also be done by means of a grinder.

The fitter's and the el. engineer's allegations that immediately after the cutting with electric welding, i.e. after 2-3 minutes, a check of the situation in the cabins on the first deck was carried out, could not be confirmed by another, objective source. The magnitude and damage of the fire has justified the following reasonable assumptions:

- highly likely, the fitter has carried out a fire safety check in the cabin after a longer period of time, enough for fire to cover the entire ceiling space, and the smoke spreading through the adjacent premises and / or the operation with electric welding for removing the part of the strap has started earlier than 1330.

4. CONCLUSIONS

4.1. MAIN CAUSE OF THE CASUALTY.

The fire on the ship has occurred as a result of hot works carried out on the outside of the messmen' cabin. The absence of smoke detectors in the residential rooms of the superstructure has also significantly contributed to the late detection of the fire.

The main cause for the very serious maritime casualty has been the failure to inspect fire safety before and during hot works from the inside/back of the messmen' cabin partition.

4.2. CONTRIBUTING CAUSES LEADING TO THE CASUALTY.

- the MSC/Circ. 1084 recommendations for the provision of fire surveillance in the adjacent premises and areas of those in which fire work is carried out have not fully implemented in the Navigation Safety Management System (procedure NMB 02/2/012 and instruction WI-02-003/ 2013);

- there has been no provision for the installation of smoke detectors in the residential rooms of the ship's superstructure;

- the decision of the fitter, to remove the rest of the strap by an electric welding, instead of by an angle grinder.

5. ACTIONS TAKEN.

An internal investigation and an investigation by the operator has been carried out. To prevent such casualties, The Navigation has undertaken the following actions:

- Revising Instruction WI-02-003 "Organization of the Fire Protection and Fire Protection Measures for the ships from NMBF JSC", completing the requirement during hot works to carry out a fire safety check in the neighboring premises and to maintain a fire watch, both for the immediate and for all potentially affected neighboring areas.

- A Safety Circular 144/April 2018 has been submitted providing for measures to improve fire safety.

- When instructing safety precautions prior to start hot works on ships, particular attention is paid to ensuring fire safety at all potentially affected neighboring / related areas before, during and after work.

- On ships operated by the Navigation a focused Fire Safety campaign has also been carried out, paying special attention to internal audits and SE checks.

- A full prophylaxis and testing of the fire detection systems on both ferries was carried out, and the exchange of temperature sensors with smoke ones or such triggering at temperatures of 60 degrees was discussed with the register.

- The incident is considered during the trimester ISM Seminars with senior command staff and is also included in the initial safety instruction.

6. SAFETY RECOMMENDATIONS.

In view of the actions taken by the operator to prevent such accidents, the Commission makes no safety recommendations.