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“Transportation of coal by sea”

DEGREE PROGRAMME IN SEA CAPTAIN'S DEGREE
2024

ABSTRACT

Smirnov Andrei: "Transportation of coal by sea"

Bachelor's thesis

Sea Captain's Degree Programme

March 2024

Number of pages: 33

The thesis was made to describe the next things: safe transportation of coal by sea, what are the risks and how to minimize them, what is coal in general and why it can be dangerous, why the coal industry is still important nowadays, presenting own experience.

The main benefit of the thesis is knowledges of the safe working practices that can help people who want to have a deal with coal in future. I explained the principles of working on bulker vessel that transports coal. For analyzing this topic I used maritime publications, different reliable resources, SOLAS and etc. Moreover I presented my own photos and documents from the previous contract to understand the idea of the topic more clearly. In conclusion I formulated the main ideas and purposes about safe working principles, shared own opinion about working on bulker fleet, and what could we do to minimize the risks associated with transportation of coal by sea.

Keywords: Transportation of coal by sea, bulk cargo, coal characteristics, dangerous cargo, safe working principles, coal industry.

CONTENTS

1 TRANSPORTATION OF COAL BY SEA/ INTRODUCTION	4
MAIN BODY	5
1.1 What is coal?	5
1.2 Coal as a bulk cargo	5
1.3 Transportation requirements for bulk cargoes other than grain	6
1.4 Loading of coal	9
2 DECLARATION FOR TRANSPORTATION OF COAL BY SEA	10
2.1 Special document	10
2.2 What are the risks of transportation of coal by sea?	13
2.3 The best practices to minimize the risks	15
2.4 Related photos	21
3 COAL INDUSTRY	26
3.1 Global coal transportation market	26
3.2 "List of countries by coal reserves"	28
3.3 Importance of coal industry	28
3.4 Coal mining	30
3.5 Prospects of the coal market	30
4 CONCLUSION	31
REFERENCES	33

1 TRANSPORTATION OF COAL BY SEA/ INTRODUCTION

The role of transport is quite important as it takes a part in the development of economy of countries, it helps to connect industry and agriculture, continents and islands, and gives us opportunity to provide our needs not only in usual life but also in business. (Docherty, I., and MacKinnon, D. (2013))

Nowadays there are different ways of logistics such as maritime transport, airplanes, trucks and etc. Transportation by sea is the most important type of logistics as around 90% of all goods are transported by maritime transport. (Foundersguide, 2019)

The global economy is quite heavily dependent on maritime transportation and every year there is an increase in demand for sea carriage.

When you work on vessels you can often hear the following phrase: "Safety first", because emergency situations are totally different from emergencies for example on trains or at shops. Evacuations at sea are more difficult and complicated. Every year there is a lot of accidents such as: human casualties, environmental disasters, and of course financial damages. That's why there are so many researches, articles, conventions and publications about safety at sea. (Maritimepage, 2023)

In the thesis I chose the topic such as "Transportation of coal by sea". It is quite interesting topic because during the study, many issues related to transport, transport safety and cargo such as coal were studied.

MAIN BODY

1.1 What is coal?

One of the most marketable goods in the modern world is energy. Coal is one of the most popular sources of it. (Smenet) Coal is a type of fossil fuel formed from parts of ancient plants underground without oxygen access. Coal, like oil and gas, is an organic substance that has undergone slow decomposition under the influence of biological and geological processes. The basis for the formation of coal is plant residues. There are three main types of coal: anthracite, brown coal, hard coal. (Urm-company) In this topic I am talking about anthracite and I will call it just "coal". This coal is mainly used at electricity generating plants. It contains 95% of carbon, hydrogen, nitrogen, sulfur and oxygen. Chemical composition: mixture of high molecular weight aromatic compounds with a high mass fraction of carbon, as well as water and volatile substances with small amounts of mineral impurities. These impurities form ash during combustion. Coal is used as a technological and energy raw material in the production of coke and semi-coke to produce a large number of chemical products (naphthalene, phenols), on the basis of which fertilizers, plastics, synthetic fibers, varnishes, paints and so on are obtained. (Geologyscience)

1.2 Coal as a bulk cargo

Bulk cargo - cargo that is unpacked or not containerized. It can be various ores, fertilizers, sugar, grain, sand and other similar cargoes. Such cargo as coal belongs to a bulk cargo. Bulk cargo has the following characteristics:

- 1) Angle of repose - the angle between the free surface of the bulk material and the horizontal plane, at which the soil remains able to maintain the maximum equilibrium. With increasing humidity, this characteristic grows.
- 2) Sagging of the load - compaction of bulk cargo due to the redistribution of cargo particles in the bulk of the embankment and the compression of the

lower layers by the upper ones. This factor depends on the properties of the cargo, the method of loading, the vibration of the vessel's hull, the duration and conditions of navigation.

3) Looseness - ability of bulk cargo to move under the influence of gravity or external dynamic forces that occur when the vessel is moving. As a result, the ship may capsize due to a large roll.

4) Stowage factor - the volume that includes 1 ton of cargo in the hold of the vessel. (Maritimepage, 2024)

5) Moisture load - the percentage of moisture in its mass. This is one of the most important characteristics of bulk cargo because self-heating, the possibility of liquefaction depend on it. As the humidity of bulk cargo increases, its weight increases and as a result, less cargo can be transported.

6) Self-ignition - it occurs due to the action of internal heat sources (chemical and biological processes in the cargo itself). Coal is especially prone to spontaneous combustion. During the storage and transportation of coal, carbon is constantly oxidized, which causes the quality and quantity of coal to decrease. And it directly depends on the temperature and type of coal. The main cause of spontaneous combustion of coal is their adsorption of oxygen and an increase of temperature due to the prolonged course of chemical reactions in coal with the formation of oxidation products, semi-oxidation, etc. Temperature of coal than is more than 35 degrees (sometimes more) is usually considered as dangerous during transportation of that cargo by sea.

7) Chemical properties - properties of cargo that manifest themselves during a chemical reaction and influence this reaction.

8) Group under IMSBC Code

9) Classification relating to MARPOL V - it helps us to understand is the cargo harmful to the marine environment or not.

10) Relevant special properties of the cargo (Owaysonline, 2021)

1.3 Transportation requirements for bulk cargoes other than grain

Transportation of non-grain bulk cargoes is regulated by SOLAS (International Convention for the Safety of Life at Sea), 1974, II-2/54.

What are the most dangerous situations that are related to transportation of bulk cargo? They can be such as a decrease or loss of stability of the vessel, chemical reactions and damage to the hull due to improper distribution of cargo. (SteamshipMutual, 2010)

The shipper is obliged to provide the captain or his representative with “declaration of the transport characteristics and safe conditions of sea transportation of solid bulk cargo”. This document must be sent in advance of loading in order to prepare the measures, equipment and instructions for the crew that are necessary for the safe transportation and loading of cargo. (SOLAS. International Convention for the Safety of Life at Sea. Chapter VI. Carriage of cargoes and oil fuels - Part A. General provisions. Regulation 2. Cargo information)

The shipper is a person who has made a contract of carriage of goods by sea with the carrier, and it can also be said that this is the person who transfers the cargo to the carrier on the basis of a contract of carriage by sea. The carrier is a person who has concluded a contract for the carriage of goods by sea with the shipper or charterer, or on whose behalf such a contract has been concluded. (ShipScience, 2024)

During transportation of solid bulk cargo by sea, a special device for measuring the concentration of gases and oxygen in the air must be on board, and detailed instructions for its use must be attached. It is necessary because bulk cargo has the ability to emit flammable and toxic gases, reduce the oxygen content in space. For example during coal transportation, it is extremely important to have accurate data on the composition of the gas in the cargo hold: coal is subject to self-heating and can emit a significant amount of methane. A cargo hold is a special space on a vessel where a certain cargo is kept. (BRITANNIA, 2021)

In addition, a certain document must be on board, translated into the official languages of the vessel's company. It should include the following things as a minimum: information about ballast tanks and their performance, stability details (rule II-1/5-1), maximum permissible load, special restrictions for this vessel if there are, strength calculations, instructions for loading and discharging regarding the strength of the vessel's hull, depending on external conditions such as weather conditions, ballast operations and incidents that may occur during a sea voyage. Before loading or discharging the master and the representative of the terminal must prepare special plan which describes the following things: the amount of cargo, the sequence of operations, required time for cargo loading/discharging taking into account the speed of ballast operations and of loading/discharging equipment. The master and the representative of the terminal should follow this plan. Moreover all cargo holds must be inspected and prepared before cargo operations. (Owaysonline, 2021)

During cargo operations, each member of the ship's crew must be familiar with safety procedures. The responsible person (it is usually the chief mate) is also determined to constantly monitor cargo operations and measure the draft of the vessel and quantity of the cargo on board and enter it in the cargo record book and ballast record book. Each vessel that transports dangerous bulk cargo must have special manifest where dangerous cargo and its stowage is mentioned. Before the departure a copy of that document must be provided to the representative of the port authorities. (Owaysonline, 2021)

There are three different groups under International Maritime Solid Bulk Cargoes (IMSBC) Code. Group A - cargo that can liquefy, can be dangerous due to moisture, which can lead to liquefaction or dynamic separation when transported with a moisture content exceeding the permissible humidity limit

for transportation. Group B - cargo which contains a dangerous chemical substance that can lead to a dangerous situation on the vessel. Group C - cargo that doesn't have any liquefaction (Group A) or a dangerous chemical substance (Group B). (Lloyd's Register. (2013). Carrying solid bulk cargoes safely)

Transportable moisture limit (TML) is the maximum safe moisture quantity in the cargo for its transportation by sea. (Lloyd's Register. (2013). Carrying solid bulk cargoes safely). The value is usually measured in percentages. Bulk cargo must be stowaged so that the vessel has sufficient stability to ensure that excessive loads never occur in the ship's structures. On the vessels that transport bulk cargo there should always be instructions on emergency actions and first aid related to incidents involving dangerous bulk cargoes. Taking into account that coal can ignite itself, it is forbidden to load it if the temperature is above transportation limit, as well as if cargo moisture is more than transportable moisture limit. As mentioned above coal emits flammable gases - methane, therefore, during transportation, it is necessary to check the amount of this gas in the cargo hold and open the ventilated hatches (in case if ventilation is required). In case of emergency, entry into the hold should be made only to those crew members who has a permit to do it, they should be dressed in special protective suits, have breathing apparatus and always be in touch with the responsible officer. (Slav Ostrowicki. (BRITANNIA, 2021)

1.4 Loading of coal

Basically, coal gets to the port by railroad, then it is discharged to the special terminal. Usually, coal is not stored in ports, as there is a high risk of its ignition. Loading onto the vessel is mostly carried out either by means of port cranes, by means of belt loading or by ship's cranes (if there are). (HandyBulk)

2 DECLARATION FOR TRANSPORTATION OF COAL BY SEA

2.1 Special document

Then I would like to show “declaration on the transport characteristics and safe conditions of sea carriage of solid bulk cargo” which is drawn up in accordance with the Convention for the Safety of Life at Sea, 1974, Chapter VI, Regulations 1.2, 2, 6 and 7, (IC SOLAS-74) with amendments, The International Maritime Solid Bulk Cargoes Code (IMSBC Code, IMO), The Code of Practice for the Safe Loading and Unloading of Bulk Carriers (BLU Code, IMO).


I made copy of that when I was the third officer on the big bulk carrier last year.

1. The certificate of the transport cargo characteristics at the time of loading

208.23/IncoUL

МОРСКОЕ ГРУЗОВОЕ БЮРО
MARINE CARGO BUREAU

Quality Management System is Certified in Compliance with ISO 9001:2015

Национальная признанная организация по безопасности морской транспортировки грузов  National Recognized Organization on the Safe Carriage of Cargoes by Sea

CERTIFICATE OF THE TRANSPORT CARGO CHARACTERISTICS AT THE TIME OF LOADING
This form meets the requirements of the IMSBC Code, Section 4, BLU Code and is issued on behalf of competent **SHIP'S ORIGINAL**

BCSN (Bulk Cargo Shipping Name): **COAL / УГОЛЬ**

TRADE NAME: Coal of grades **KSN, D, KO, K, GZh, GZhO, Zh**
Уголь каменный марок **KCH, D, KO, K, ГЖ, ГЖО, Ж**

1 Shipper / Грузоотправитель: [Redacted]	2 Transport document No. / Номер грузового документа: Reg. No. [Redacted]
3 Consignee / Грузополучатель: TO ORDER	4 Name of ship / Название судна [Redacted]
5 Port of loading / Порт загрузки: [Redacted]	6 Estimated Date of Loading / Ожидаемая дата погрузки April 29 – May 05, 2023
7 Port of discharging / Порт выгрузки: TO ORDER	8 Instructions or other matters / Инструкции или иные указания See Declaration No. [Redacted]
9 General description of cargo / Общее описание груза: It is a natural, solid, combustible material.	10 Quantity of cargo, weight / Количество груза, вес: 30 000 ±10% MT
11 Specifications of bulk cargo / Характеристики груза: Stowage factor / Удельно-погрузочный объем: 1,2 m³/t Fraction less 1 mm / Фракция менее 1 мм: 18,0% Fraction less 10 mm / Фракция менее 10 мм: 65,0% Temperature / Температура: +10°C	<i>Зарегистрировано в ФАУ «Российский морской регистр судоходства»</i> Registered in Russian Maritime Register of Shipping Reg.No / Пер.№ CBC.23.43661.382 Of/от April 29, 2023
Angle of repose / Угол естественного откоса: Not applicable / Не применяется, Has cohesive / Имеет сцепление	
Trimming procedures / Порядок штивки: See Section 5 of IMSBC Code and Declaration No. MCB-D.11.5945.23	
Chemical properties / Химические свойства: UN No. is not applicable, Class or Div. – MHB (SH, WF, WT, CR, OH), See Declaration No. MCB-D.11.5945.23	
Group under IMSBC Code / Группа по IMSBC Code: <input checked="" type="checkbox"/> Groups A and B <input type="checkbox"/> Group A <input type="checkbox"/> Group B <input type="checkbox"/> Group C	Transportable moisture limit (TML) / Транспортный предел влажности: 22,1% Date of TML Test, see Declaration No. MCB-D.11.5945.23
Classification under MARPOL Annex V/Классификация по МАРПОЛ/Прил. V: <input type="checkbox"/> harmful to the marine environment <input checked="" type="checkbox"/> not harmful to the marine environment	Moisture content at shipment / Влажность при отгрузке: 15,0%
12 Relevant special properties of the cargo / Особые свойства груза: See Declaration No. MCB-D.11.5945.23	13 Additional documents / Дополнительные документы: - Declaration Reg. No. MCB-D.11.5945.23; - Reference of sampling / Справка об отборе проб.

DECLARATION / ДЕКЛАРАЦИЯ
I hereby declare that the consignee is fully and accurately described and that the given test results and other specifications are correct to the best of my knowledge and belief and can be considered as representative for the cargo to be loaded.
Настоящим заявляю, что партии груза описаны полностью и точно и что приведенные испытания и другие характеристики являются представительными для груза, подлежащего загрузке.

RECEIPT: **ПОЛУЧЕНО:** [Redacted]




On Behalf of shipper / По поручению грузоотправителя
[Redacted]

Межевой канал, дом 4, г. Санкт-Петербург, Россия, 198035 4, Mezhevoy canal, St. Petersburg, Russia, 198035
Phone: +7(812) 647-09-30 Fax: +7(812) 647-09-34 www.mcb-spb.ru mcb-public@mcb-spb.ru

It tells us about Bulk Cargo Shipping Name, trade name, who is shipper and consignee, port of loading and discharging, name of ship, estimated date of

loading, instructions and quantity of cargo. After that, bulk cargo characteristics are mentioned: stowage factor, fractions, temperature (+10 degrees, so it is safe to load), angle of repose (in this case it is not applicable and has cohesive), trimming procedures, chemical features, this cargo is indicated as Group A and B and it is not harmful to the marine environment, moisture of coal is also safe for loading, it is 15% (TML is 22,1%). (National Recognized Organization on the Safe Carriage of Cargoes by Sea. CERTIFICATE OF THE TRANSPORT CARGO CHARACTERISTICS AT THE TIME OF LOADING)

1. The reference from the laboratory

 МОРСКОЕ ГРУЗОВОЕ БЮРО MARINE CARGO BUREAU <i>Quality Management System is Certified in Compliance with ISO 9001:2015</i>	
<i>Национальная признанная организация по безопасности морской транспортировки грузов</i>  <i>National Recognized Organization on the Safe Carriage of Cargoes by Sea</i>	
<i>Межевой канал, дом 4, офис 301, г. Санкт-Петербург, Россия, 198035</i> <i>4, Mezhevoy canal, office 301, Saint-Petersburg, Russia, 198035</i> <i>Tel. +7 (812) 647 0930, Fax +7 (812) 647 0934, http:// www.mcb-spb.ru, e-mail: mcb-public@mcb.spb.ru</i>	
Справка / Reference Об отборе проб для определения сертифицируемых параметров Of sampling for definition of the parameters of the cargo to be certified Reg. No. [REDACTED]	
Груз: Cargo:	Coal of grades KSN, D, KO, K, GZh, GZhO, Zh Уголь каменный марок KCH, Д, КО, К, ГЖ, ГЖО, Ж
Место расположения штабеля: Stockpile position:	[REDACTED]
Грузоотправитель: Shipper:	[REDACTED]
Название т/х: Name of the ship:	[REDACTED]
Порт погрузки: Port of loading:	[REDACTED]
Отбор проб и определение транспортных характеристик груза проведены испытательной лабораторией ЗАО «МОРСКОЕ ГРУЗОВОЕ БЮРО», лабораторный пост Усть-Луга СВИДЕТЕЛЬСТВО О ПРИЗНАНИИ ИСПЫТАТЕЛЬНОЙ ЛАБОРАТОРИИ № 16.00067.383 выданный Российским морским регистром судоходства 02.11.2016 и в соответствии с требованиями: Sampling and definition of cargo transport characteristics are carried out by "MARINE CARGO BUREAU", JSC laboratory office Ust-Luga test laboratory, RECOGNITION CERTIFICATE OF TESTING LABORATORY No. 16.00067.383, issued by Russian Maritime Register of Shipping" on November 02, 2016 and under the following demands:	
<ol style="list-style-type: none"> 1 Международного кодекса морской перевозки навалочных грузов (IMSBC Code, IMO), с поправкой 04-17 International maritime safety bulk cargoes code (IMSBC Code, IMO), incorporation amendment 04-17 2 Руководством по отбору проб, определению и контролю влажности твердых навалочных грузов склонных к разжижению при отгрузках в морских портах РФ. Reg. No. MCB-LCG.001.14 Guidelines for sampling, testing and controlling the moisture content for solid bulk cargoes which may liquefy in sea port of Russia, Reg. No. MCB-LCG.001.14 	
По поручению грузоотправителя On behalf of the shipper  April 29, 2023	

On the second page there is the reference which gives information that the parameters of the cargo were certified. (MARINE CARGO BUREAU, JCS laboratory. Sampling and definition of cargo transport characteristics)

2.2 What are the risks of transportation of coal by sea?

On the next pages we will see “Declaration of the transport characteristics and safe conditions of sea carriage of solid bulk cargo”. It includes following information: name of the cargo, who produced it, shipper details, cargo information, classification under MARPOL Annex V, cargo description, cargo size grading, physical characteristics of the cargo, slopes stability characteristics under the IMSBC Code, IMO, cargo transportable hazards. Then this declaration also includes requirements and measures that provide safe carriage of cargo: what kind of construction is ship and which equipment must be there, cargo plan requirements, loading requirements and what measures should be checked to provide safe cargo handling. (MARINE CARGO BUREAU, JCS laboratory. Sampling and definition of cargo transport characteristics)

2. Declaration of the transport characteristics and safe conditions of sea transportation of solid bulk cargo

Declaration of the transport characteristics and safe conditions of sea transportation of solid bulk cargo (DBC), Reg. No. [REDACTED]		Page 2 of 4
Valid until August 15, 2023.		
<u>Cargo information</u>		
Bulk Cargo Shipping Name (BCSN)	COAL	
Group according to the IMSBC Code, IMO	B (and A)*	
Class of hazard according to the IMSBC Code, IMO	MIIB (SH, WF, WT, CR, OH)	
UN. No	Not applicable	
Medical first aid	Refer to the MFAG as amended ⁽¹⁾	
* Sieving test of cargo consignment should be made for determination. Determination of fractions 0-1mm and 0-10mm, transportable moisture limit, and moisture of cargo at the time of loading, assigning of cargo shipment to groups "A" and "B" or group "B" are carried out by company recognized by Russian Maritime Register of Shipping and specified in the certificate of transport characteristics at time of loading. Russian Maritime Register of Shipping should approve the certificate.		
<u>Classification under MARPOL Annex V</u>		
MARINE POLLUTANT	NO	
CARGO RESIDUES ARE NOT HARMFUL TO THE MARINE ENVIRONMENT		
<u>Cargo description</u>		
Typical coal mass, consisting of pieces, sized as stated below.		
<u>Cargo size grading</u>		
Fraction classes: Sh 0-6 mm, SSh 0-13 mm, MSSh 0-25 mm, OMSSh 0-50 mm, S-6-13 mm, M 13-25 mm, PK 50-250 mm, PKO 25-250 mm, OM 13-50 mm, OMS 6-50 mm, r(run-of-mine grade) 0-200(300)mm.		
<u>Physical characteristics of the cargo</u>		
Stowage factor (SF), m ³ /t	0,79 - 1,53 ⁽²⁾	
Bulk Density (BD), kg/m ³	654 - 1266 ⁽²⁾	
Transportable moisture limit (TML), %	See Supplement to Declaration	
<u>Slopes stability characteristics under the IMSBC Code, IMO</u>		
Cargo classification of the cohesion availability	Cohesive	
Angle of repose, deg.	Not applicable	
<u>Cargo transportable hazards</u>		
The declared coal is referred to the cargoes, included in the IMSBC Code, IMO, Groups "B" and "A": i.e. referred to the cargoes, which in sea transportation may liquefy or dynamic separation if shipped at a moisture content in excess of their transportable moisture limit and following chemical hazard.		
- coal may emit methane, a flammable gas. A methane/air mixture containing between 5% and 16% methane constitutes an explosive atmosphere. Methane is lighter than air and may, therefore, accumulate in the upper region of the cargo space and other enclosed spaces (WF);		
- coal may be subject to oxidation, leading to depletion of oxygen and an increase in carbon dioxide concentration in cargo space (OH);		
- be liable to self-heating, that could lead to spontaneous combustion in the cargo spaces (SH). Flammable and toxic gas, including carbon monoxide, produces. Carbon monoxide is an odorless gas, slightly lighter than air, and has flammable limits in air of 12% to 75% by volume. It is toxic by inhalation (WF, WT);		
- may be liable to react with water and produce acids which may cause corrosion (CR). Flammable and toxic gas, including hydrogen, produces. Hydrogen is an odorless gas, much lighter than air, and has flammable limits in air of 4% to 75% by volume (WF, WT).		
- can liquefy if the particles less than 1mm more than 10% by weight ⁽²⁾ and/or particles less than 10mm more than 50% by weight ⁽²⁾ .		
On degree of influence at human organism the declared cargo is referred to IV class hazardous substances (low-hazard substance) under the Specifications GOST 12.1.005-88 and GOST 12.1.007-76. Coal dust cause skin disease influenced on mucous membranes of eyes and breathing ways.		
¹ MFAG - The IMO/WHO/ILO Medical First Aid Guide for Use in Accidents Involving Dangerous Goods is the Chemicals Supplement to the International Medical Guide for Ships (IMGS).		
² The values of the stowage factor, bulk density, moisture content and fines content of the cargo are determined during the consignment certification.		


As was described before, transportation of coal has a lot of risks and can be dangerous. The presented declaration clarifies these hazards more detailed.

The declared coal may emit flammable gas - methane. The atmosphere starts to be explosive if methane/air mixture contains between 5% and 16% methane. Each gas has different weight, in this case methane is lighter than air so it goes up. That's why the highest places of the cargo hold have more quantity of this gas. There is a possibility in the lack of oxygen in cargo space because of oxidation of coal. As was mentioned above coal is self-heating cargo that could lead to combustion and producing of toxic gas (carbon monoxide) in the cargo hold. This gas is very harmful for breathing, and it has low flammable limits. Moreover, corrosion is also the reason for the interaction of this cargo with water. During this process, odorless and flammable gas hydrogen is produced. The declared cargo is low-hazard substance, but it is still can be harmful for human health as coal dust getting into the eyes or respiratory tract can cause skin diseases. Considering the above information, coal can be a dangerous cargo and there are real risks of hazardous situations. (National Recognized Organization on the Safe Carriage of Cargoes by Sea. Declaration of the transport characteristics and safe conditions of sea transportation of solid bulk cargo)


2.3 The best practices to minimize the risks

On the next two pages of the declaration, requirements and measures to provide safe carriage of cargo are well explained.

4.1 Requirements and measures to provide safe carriage of cargo

	Declaration of the transport characteristics and safe conditions of sea transportation of solid bulk cargo (DBC), Reg. No. [REDACTED] Valid until August 15, 2023.	Page 3 of 4
REQUIREMENTS AND MEASURES TO PROVIDE SAFE CARRIAGE OF CARGO		
<u>Requirements to construction and equipment of ship</u>		
<p>The ship, enlisted to transportation of the cargo, is to have documentation, approved by the Classification association, which is to confirm the fitness of the ship for transportation of the declared cargo in bulk.</p>		
<p>All electric cables and components situated in cargo spaces should be free from defects. Such cables and electrical components should be safe for use in an explosive atmosphere or positively isolate.</p>		
<p>The ship should be suitably fitted and carry on board appropriate instruments for measuring the following without requiring entry in the cargo space:</p>		
<ol style="list-style-type: none"> 1. concentration of methane in the atmosphere; 2. concentration of oxygen in the atmosphere; 3. concentration of carbon monoxide in the atmosphere; 4. pH value of cargo holds bilge samples. 		
<p>It is recommended that means be provided for measuring the temperature of cargo in the range 0-100°C.</p>		
<p>In accordance with SOLAS 74 with Amendments, Rule VI/6.3, Rule II-2/19.3.6 at least two self-contained breathing apparatuses and four sets of full protective clothing resistant shall be provided in addition to the fire-fighter's outfits, which may use trained persons only.</p>		
<u>Requirements to cargo plan</u>		
<p>In accordance with SOLAS 74 with Amendments, Rule VI/6, Rule VI/7, Resolution IMO A.787.19, App. 4.39 the ship shall be provide with a BULK CARRIER BOOKLET, including "Information on Ship's Stability" with typical cargo plan for cargo with SF in range 0,9-1,3 m³/t.</p>		
<p>The cargo plan should be drawn up in respect of the general requirements for stability and strength of the ship and features of the declared cargo, stated in part Cargo transportable hazards of the present Declaration.</p>		
<p>The non-shiftability of the cargo provide by stowing in accordance with Sections 4 and 5 of IMSBC Code, IMO. A height of the cargo layer on the steel plating near the board of the ship should not be less than 2 m.</p>		
<p>The master should ensure that the cargo is not stowed adjacent to hot areas.</p>		
<p>"SEPARATED FROM" goods of classes 1 (Division 1.4), 2, 3, 4 and 5 in packaged form (see IMDG Code) and "SEPARATED FROM" solid bulk materials of classes 4 and 5.1. Stowage of coal of class 5.1 in package form or solid bulk materials of class 5.1 above or below a cargo should be prohibited. The cargo should be "SEPARATED LONGITUDINALLY BY AN INTERVENING COMPLETE COMPARTMENT OR HOLD FROM" goods of class 1 other Division 1.4.</p>		
<u>Requirements at loading</u>		
<p>The loading may be commenced only at reception of the documents, specified in a final part of the present Declaration by the Administration of the ship.</p>		
<p>This cargo shall only be accepted for loading when the temperature of cargo is not higher than 55°C.</p>		
<p>All cargo spaces and bilge wells should be clean and dry. Any residue of waste material or previous cargo should be removed, including removable cargo battens, before loading.</p>		
<p>When a cargo is carried in a ship other than a specially constructed or fitted cargo ship complying with the requirements in subsection 7.3.2 of this Code, the following provisions shall be complied with:</p>		
<ol style="list-style-type: none"> 1. the moisture content of the cargo shall be kept less than its TML during voyage; 2. the cargo shall not be handled during precipitation; 3. during handling of the cargo, all non-working hatches of the cargo spaces into which the cargo is loaded or to be loaded shall be closed; 4. the cargo may be handled during precipitation provided that the actual moisture content of the cargo is sufficiently less than its TML so that the actual moisture content is not liable to be increased beyond the TML by the precipitation; 5. the cargo in a cargo space may be discharged during precipitation provided that the total amount of the cargo in the cargo space is to be discharged in the port. 		
<u>Measures to provide safe cargo handling</u>		
<p>According to general requirements IMSBC Code, IMO during cargo handling it is taken into account the cargo transportation hazards. The crew and personnel, engaged in cargo operations, are to be informed about the cargo hazards.</p>		
<p>Adequate measures shall be taken to prevent liquids entering the cargo space in which these solid bulk cargoes are stowed during the voyage.</p>		

4.2 Requirements and measures to provide safe carriage of cargo

 Declaration of the transport characteristics and safe conditions of sea transportation of solid bulk cargo (DBC), Reg. No. [REDACTED] Page 4 of 4
Valid until August 15, 2023.

The appearance of the surface of this cargo shall be checked regularly during voyage. If free water above the cargo or fluid state of the cargo is observed during voyage, the master shall take appropriate actions to prevent cargo shifting and potential capsizing of the ship, and give consideration to seeking emergency entry into a place of refuge.

Masters shall be cautioned about the possible danger of using water to cool these cargoes while the ship is at sea. Introducing water may bring the moisture content of these cargoes to a flow state. When necessary, due regard shall be paid to apply water in the form of spray.

Smoking and the use of naked flames should not be permitted in the cargo areas and adjacent spaces and appropriate warning notices should be posted conspicuous places. Burning, cutting, chipping, welding or other sources of ignition should not be permitted in the vicinity of cargo spaces or in other adjacent spaces, unless the space has been properly ventilated and the methane gas measurements indicate it is safe to do so.

Prior to departure, the master should be satisfied that the surface of the cargo has been trimmed reasonably level to the boundaries of the cargo space to avoid the formation of gas pockets and to prevent air from permeating the body of the coal.

It is necessary regularly monitoring of atmosphere in cargo holds and adjacent spaces. The hatches should be closed immediately after completion of loading. The hatch covers can also be additionally sealed with RAM-NEK tape, MAKROFLEX or other.

Methane concentration should be not more 20% of the LEL (Low Explosion Limit, LEL CH₄ - 5%). Surface ventilation should be limited to the absolute minimum time necessary to remove methane. Forced ventilation should not be used. On no account should air be directed into the body of the coal as air could promote self heating.

If the carbon monoxide level is increasing steadily, a potential self-heating may be developing. The cargo space should be completely closed down and all ventilation ceased. Master should seek expert advice immediately.

Regular hold bilge testing should be systematically carried out. If the pH monitoring indicates that the corrosion risk exists, the master should insure that all bilges are kept dry during the voyage in order to avoid possible accumulation of acids on tank tops and in the bilge system.

The instrumental remote gas control should be carried out by specially trained ship's crew member. A person, responsible for measurements should stay out of hold. Gas control procedure is stated in COAL INDIVIDUAL SCHEDULE (IMSBC Code, IMO).

Entering into the cargo spaces is allowed only at opened hatch covers after 2-hours ventilation of the hold. Minimal allowable concentration of the oxygen should not be less, then 20% vol.

Entrance personnel into closed spaces allowed only specially trained persons at Master's notification obeying the Recommendations for entering enclosed spaces aboard ships (Res. IMO A.1050(27), adopted on 30 November 2011). For entry into a space where the atmosphere is known or suspected to be unsafe it necessary use the self-contained breathing apparatuses.

IN THE EVENT OF FIRE: Batten down. Exclusion of air may be sufficient to control the fire. **Do not use water.** Seek expert advice and consider heading to the nearest port.

REMARKS: The use of CO₂ or inert gas, if available, should be withheld until fire is apparent.

Individual protection means should be used while handling the cargo: respirators, protective suits, closed goggles, working gloves, shoes or boots.

At the moment of loading the following documents should be submitted on board of the vessel:

1. DECLARATION on the transport characteristics and safe conditions of sea carriage of solid bulk cargo;
2. Supplement to Declaration: Certificate of evaluation to determination of flow moisture point (FMP) and transportable moisture limit (TML);
3. Reference of sampling;
4. Certificate of the cargo characteristics at the moment of loading with stated stowage factor, bulk density, moisture content, fractions 0-1mm and 0-10mm and temperature values.

The ship owner should inform the shipper about unforeseen circumstances connected with the cargo carriage, so that the information provided in the Declaration can be reviewed in the light of transport experience.

Firstly, the ship needs to have special documentation, which is approved by the Classification association, that declares that this vessel is suitable for transportation of the declared cargo in bulk. Also, all electrical cables and components located in explosive atmospheres must be suitable for use, as well as free from any defects. For safe transportation of the declared cargo, the vessel must be provided with the equipment necessary to measure the following things without entering the cargo area itself:

1. methane concentration in the atmosphere;

2. carbon monoxide concentration in the atmosphere;
3. oxygen concentration in the atmosphere;
4. pH value of cargo holds bilge samples.

Also, it is recommended that there is a special equipment for measuring the cargo temperature in the range 0-100 degrees.

Moreover, in addition to the fire-fighter's sets, minimum four outfits of full protective clothing resistant and two self-contained breathing apparatuses should be equipped. SOLAS 74 with Amendments, Rule VI/6.3, Rule II-2/19.3.6 requires that. (National Recognized Organization on the Safe Carriage of Cargoes by Sea. Declaration of the transport characteristics and safe conditions of sea transportation of solid bulk cargo)

Secondly, "bulk carrier booklet" that includes "Information on Ship's Stability" with typical cargo plan for cargo that has "stowage factor" between 0,9 and 1,3 m³/t in accordance with SOLAS 74 with Amendments, Rule VI/6, Rule VI/7, Resolution IMO A.787.19, APP. 4/39. The cargo plan should be prepared in accordance with the parameters of the vessel, characteristics and hazards of the declared cargo that were stated above. The cargo should not have possibility to shift, in that case stowing must be done according to Sections 4 and 5 of IMBSC Code, IMO. Also, the height of the cargo which is on the bottom and near the board of the ship should be minimum two meters. No stowing to hot places should be provided by the captain. (National Recognized Organization on the Safe Carriage of Cargoes by Sea. Declaration of the transport characteristics and safe conditions of sea transportation of solid bulk cargo)

Thirdly, it explains safe working practices and requirements during loading operations. There is the temperature limit for loading of the declared coal - 55 degrees. Moreover, all cargo spaces and bilges should be dry and clean (after the previous cargo). (National Recognized Organization on the Safe Carriage of Cargoes by Sea. Declaration of the transport characteristics and safe conditions of sea transportation of solid bulk cargo)

In accordance with subsection 7.3.2 of that Code, if the vessel does not comply with this statement but still it transports a cargo, the following conditions must be met:

1. Cargo moisture should be less than TML during transportation.
2. During precipitation, it is prohibited to handle the cargo.
3. All non-working hold covers must be closed, if the cargo is loading into them or has already been loaded during cargo handling.
4. However, it is still possible to process the cargo, provided that the moisture content in the cargo is significantly less than TML and that during precipitation it will not become higher than TML.
5. Also, in case of precipitation, the cargo can be unloaded at the destination port, provided that the whole amount of it is unloaded. (IMO. IMSBC Code. Subsection 7.3.2)

Next measures describe how to provide safe cargo handling. All crew and workers who are engaged in cargo operations should be informed about the cargo hazards. No any liquids are allowed to enter the cargo holds during stowing of the cargo. External inspections of the cargo surface should also be carried out regularly by the responsible crew members. So, when it is established that the cargo becomes liquid or water appears above the cargo, the captain is obliged to take appropriate measures to avoid shifting of the cargo or loss of stability of the vessel. And it is also necessary to consider the availability of a shelter place for the vessel. Captains should be notified of the danger of using water to cool the cargo during sea-voyage, as this may contribute to an increase the moisture in the cargo that leads to flow state. You also need to be careful when applying water with splashes. Smoking is prohibited, as well as sources of open fire (for example lighters) near cargo holds and directly in the cargo areas themselves, special signs of that restriction should be visible on the vessel. The use of things such as welding, grinding, burning, chipping, cutting (sources of fire) is not allowed near cargo spaces but it can be made if the place is properly ventilated, and the methane content is safe. At the end of cargo operations, the captain must make sure that the cargo is laid flat enough, thereby there is no risk for the

formation of so-called gas pockets. The cargo hold atmosphere should be checked regularly. (IMO. IMSBC Code. Incorporation amendment 06-21)

Low Explosion Limit (LEL) of methane (CH₄) is 5%. The methane concentration should not exceed 20% of this limit. Forced ventilation directed at coal can be dangerous, as it promotes self-heating of coal. If, during measurements, it turns out that the carbon monoxide level increases, the ventilation of the hold should be stopped immediately. The captain should ask the experts for advice immediately. Regular testing of the cargo hold bilges should be ensured. If pH level rises, it is necessary to ensure that all hold bilges are dry and there is no risk of possible acid accumulation on the surface on the tank tops and in the bilge system. (National Recognized Organization on the Safe Carriage of Cargoes by Sea. Declaration of the transport characteristics and safe conditions of sea transportation of solid bulk cargo)

A specially trained crew member must take measurements using a special gas measuring device. When performing testing, the responsible person must be outside of the cargo hold. A clear action plan for this procedure should be specified in the "Coal Individual Schedule" (IMO. IMSBC Code. Incorporation amendment 06-21)

If it is necessary to enter the cargo area itself, the following conditions must be met: the oxygen content in the air is at least 20% and the hold was ventilated by using open cargo hold hatches for two hours. The entrance to the cargo area can only be performed by a specially trained person and with the Master's notification that compete all recommendations for entering enclosed spaces on ships. If the atmosphere in the cargo hold is not safe, it is necessary to use self-contained breathing apparatus. (IMO. (2011, November 30). Res. IMO A.1050(27))

In case of fire, all ventilation of the hold must be stopped, thereby there is no possibility that air will enter the cargo hold. This may help to control the fire. It is forbidden to use water. It is necessary to contact specialists and explore

the possibility of further passage of the vessel to the nearest port. To use CO₂ or inert gas, it is necessary to make sure that the ignition is obvious. The following equipment must be used during cargo operations: safety shoes, working gloves, closed goggles, protective suits, helmets and respirators. The following documents must be submitted on board of the vessel at the moment of loading:

1. Declaration on the transport characteristics and safe conditions of sea carriage of solid bulk cargo;
2. Supplement to Declaration: Certificate of evaluation to determination of flow moisture point (FMP) and transportable moisture limit (TML);
3. Reference of sampling;
4. Certificate of the cargo characteristics at the moment of loading with stated stowage factor, bulk density, moisture content, fractions 0-1mm and 0-10mm and temperature values. (National Recognized Organization on the Safe Carriage of Cargoes by Sea. Declaration of the transport characteristics and safe conditions of sea transportation of solid bulk cargo) (National Recognized Organization on the Safe Carriage of Cargoes by Sea. Declaration of the transport characteristics and safe conditions of sea transportation of solid bulk cargo)

2.4 Related photos

Next, I would like to show some photos that I made on the contract.

Photo 1 (made by my)



Photo 2 (made by me)



Photo 3 (made by me)



Photo 4 (made by me)



Photo 5 (made by me)



Photo 6 (made by me)



Photo 7 (made by me)



3 COAL INDUSTRY

3.1 Global coal transportation market

Since the beginning of 2023, global coal shipping has increased by 20%

The trend towards an increase in coal imports worldwide, which began at the end of 2022, continued in the first quarter of this year. (Earth&Human, 2022)

Thus, the global volume of coal transportation, excluding cabotage, in January-March amounted to 310.8 million tons. Compared to the same period last year, they increased by 20.5%. In January-March 2023, coal exports from Indonesia increased by 61.3% to 106.5 million tons, while from Australia decreased by 5.0% to 80.7 million tons. Coal imports from Russia increased by 23.8% to 44.5 million tons. Import figures to the United States also increased by 28.8%. Asian countries are also regaining their market activity. Thus, in the first quarter of 2023, coal imports by sea to China increased by 101.4% to 77.9 million tons, India — by 14.9% to 47.7 million tons, to Japan by 0.9% to 44.5 million tons. The main major importers of coal are Asian countries: China, India, Japan, and South Korea. In these countries, coal continues to be one of the most important sources of fuel for electricity generation. (World Ports Org., 2024)

For more than 30 years, China has been a leader in coal mining and, at the same time, its largest consumer and importer. China buys more metallurgical coal than energy coal. This is due to the deterioration of the environmental situation in recent years. The country is forced to gradually reduce its own coal production, but at the same time increases imports to maintain the growth rate of its economy. The course is set for the development of renewable energy sources: the number of nuclear power plants and hydroelectric power plants is growing. However, the needs of Chinese metallurgists in obtaining coking coal remain high. In India, a significant part

of imports is coal, because more than half of the energy is generated by heat generating stations. However, India also plans to gradually switch to "green energy" and reduce coal imports. Japan and South Korea, due to the acute problem of environmental conservation, do not carry out their own production, but import mainly metallurgical coal and to a lesser extent energy for power plants. (Yakov & Partners, 2023)

The European Union is now the fifth largest maritime importer of coal in the world after China, India, Japan and South Korea. In 2022, the EU accounted for 9.8% of all global coal shipping. In 2022, sea coal imports to the EU countries increased by 33.8% compared to the same period last year to 116.5 million tons. A year earlier, there was also an increase of 30.1% over the year to 87.1 million tons. The most important supplier of coal to Europe in 2022 was the United States, which accounted for 20.5% of imports, Australia - 19,7%, Colombia - 14,3%. (World Ports Org., 2024)

3.2 “List of countries by coal reserves”

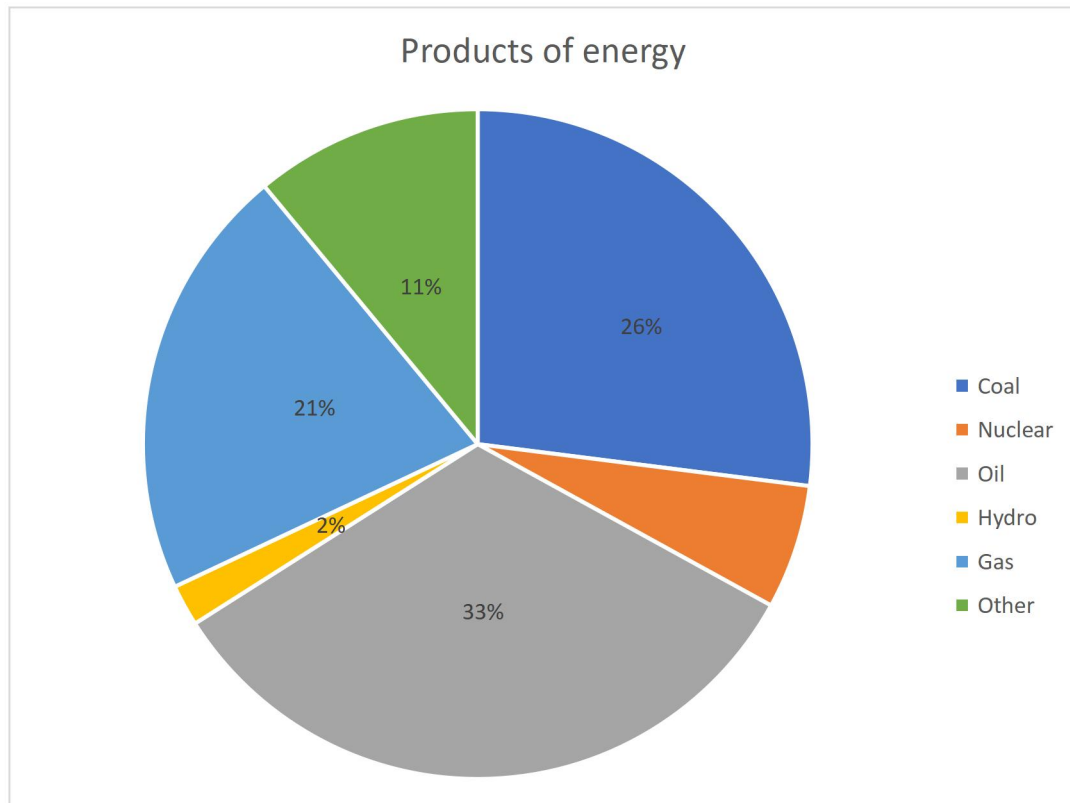
Country	Tonnes (mil)	% from the world's supply
USA	250,219	24
RUSSIA	160,364	15
AUSTRALIA	147,489	14
CHINA	138,819	13
INDIA	101,333	10
INDONESIA	37,000	4
GERMANY	36,100	3
UKRAINE	34,375	3
KAZAKHSTAN	26,479	3
SOUTH AFRICA	24,700	2

(Geeksforgeeks, 2024)

This table helps us understand that there is quite a lot of coal on the planet, but most of its reserves are located only in 10 countries. That's why coal transportation is an important topic, and shipping by sea allows it to be done in much larger quantities. After all, most of the cargo is delivered through ports, and the economies of maritime countries are very dependent on maritime logistics. (Maritimepage, 2023)

3.3 Importance of coal industry

Coal is a very important energy component. If we imagine the global balance of energy consumption by sources of its production, we will see that coal still occupies a leading position in energy generation. (Smenet)



So as we can see from the table, coal industry is a very important sphere in the global energy market. (Themminimalistvegan, 2023)

Nowadays the interest and potential demand of coal is now declining worldwide, as it is the least environmentally friendly fuel. More and more environmentally friendly fuels, such as gas, atomic energy (nuclear energy), are becoming more and more widespread in energy generation, and, of course, the main trend of recent times is renewable "green" energy. (Themminimalistvegan, 2023)

Metallurgical or coking coal is most commonly used in the steel industry. Almost 75% of all steel produced in the world is produced using metallurgical coke. Metallurgical coke is not found in nature. It is produced from a special grade of coal, which is subject to the coking process (also called coking coal). Metallurgical coke is obtained by processing coal at high temperature without oxygen access (this is coal coking). This element is a fairly rare coal, only about 20% of it is subject to coking. Therefore, this type of coal is most in

demand and extremely important for the metallurgical industry. (Bruno Venditti. (Visualcapitalist, 2022)

In this case if coal, as the main type of fuel, has been actively displaced and replaced by more environmentally friendly types of generation in energy sphere, currently there are no alternatives to metallurgical coal. This factor will certainly contribute to a further increase in demand for coking coal due to the growth of steel production in the world. (Smenet)

3.4 Coal mining

Today there are 10 leaders of coal production:

CHINA	4430 million tons
INDIA	937 million tons
USA	540 million tons
AUSTRALIA	459 million tons
INDONESIA	690 million tons
RUSSIA	440 million tons
SOUTH AFRICA	225 million tons
GERMANY	131 million tons
KAZAKHSTAN	109 million tons
POLAND	107 million tons

Many countries have sufficient coal reserves, but their extraction is mainly focused on meeting domestic needs, not on exports. About 20% of the world's coal production is sold on world markets. (Geeksforgeeks, 2024)

3.5 Prospects of the coal market

Prospects of “normal” (energy) coal: at the moment they can be described as extremely ambiguous and very vague. (Earth&Human, 2022) The global

factor pressing on the global demand for this type of fuel is the trend towards the use of more environmentally friendly fuel sources (in particular, the use of liquefied natural gas) and the creation of alternative renewable sources of electricity. (Yakov & Partners, 2023)

Prospects of metallurgical coal - the prospects for metallurgical coal depend almost entirely on the steel market. In fact, being the main fuel for steel production, the demand for metallurgical coal is highly dependent on the demand for steel. This means that prices for metallurgical coal and steel also fluctuate significantly. If energy coal is under pressure due to the availability of other more environmentally friendly fuel alternatives, however, there are currently no alternatives to the use of coking coal in metallurgy. (Yakov & Partners, 2023)

4 CONCLUSION

In conclusion I would also like to mention the following interesting facts of my own experience regarding the safe transportation of coal by sea: I worked as a Third officer and during voyages between ports, my duty except officer of the watch (OOW) was safety on the vessel, I was responsible for fire-fighting equipment (FFE) and for life-saving appliances (LSA). But as concerns time at ports, the Second officer and I had watches 6/6, we checked gangway watches, mooring lines and also helped Chief Officer (CO) to monitor cargo operations. In fact, on that bulk carrier, the CO was responsible for loading and discharging cargo, he also kept the daily logbook where CO stated the results of temperatures and gas content in cargo holds.

Working at sea is very exciting and interesting job. Yes, it is true, but sometimes there are situations when life hangs in the balance from death. Logistics, the economy of some countries, factors affecting the quality of human life, all this directly or indirectly depends on transportation of goods by

sea. Coal, in turn, is one of the most popular cargoes in the world and one of the main sources of energy, so the transportation of coal by sea was the topic that I chose to write my thesis. Of course, transportation by sea always presents risks, but coal, since it is a bulk cargo, has special characteristics and risks for transportation. That's why it is so important to take precautions and comply with all requirements for the safe transportation of coal by sea. All these rules, precautions and recommendations are not just made up, they are based on real situations, and require unquestioning implementation. How could the risks be minimized? To do this, it is necessary that each crew member knows his duties and fulfills them, does not violate safety regulations and that all safety measures for the transportation of coal by sea are met. I hope that this Thesis will be helpful and interesting especially to those people who would like to work at sea or already work. It is quite nice to work on the bulk carrier fleet, because in my opinion this is a very interesting and responsible job. And I would also like if this thesis could help in reducing the number of dangerous situations during transportation of coal by sea.

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