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Bulk Cargo Safe Carriage And Monitoring

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Abstract

This thesis investigates the critical aspects of ensuring safe transportation and monitoring of bulk cargoes on bulk carriers. By examining bulk cargo characteristics, crew member instructions, and expert advice, the research aims to identify key challenges and develop recommendations for improving safety practices.

The study highlights the unique properties of various bulk cargoes, including density, moisture content, temperature sensitivity and hazardous properties. It explores how these characteristics can impact vessel stability, cargo integrity, and crew safety. Additionally, the thesis examines the importance of comprehensive training and clear instructions for crew members to effectively handle bulk cargoes and respond to potential emergencies.

Through interviews with experienced maritime professionals, the research provides valuable insights into industry practices and challenges. The findings highlight the need for continuous improvement in safety protocols, technological advancements, and regulatory frameworks to enhance the safety of bulk carrier operations.

Keywords: bulk carriers, safe carriage, cargo monitoring, safety protocols, risk management, maritime industry.

Περίληψη

Αυτή η εργασία διερευνά τις κρίσιμες πτυχές της διασφάλισης μεταφοράς και παρακολούθησης των χύδην φορτίων μέσω πλοίου. Εξετάζοντας τα χαρακτηριστικά των χύδην φορτίων, των οδηγιών προς τα μέλη του πληρώματος και των συμβουλών των ειδικών, η έρευνα στοχεύει στην αναγνώριση των βασικών προκλήσεων και στην ανάπτυξη συστάσεων για τη βελτίωση των πρακτικών ασφαλείας.

Η μελέτη επισημαίνει τις μοναδικές ιδιότητες των διαφόρων χύδην φορτίων, συμπεριλαμβανομένης της πυκνότητας, της περιεκτικότητας σε υγρασία, της ευαισθησίας στη θερμοκρασία και των επικίνδυνων ιδιοτήτων. Εξετάζει πώς αυτά τα χαρακτηριστικά μπορούν να επηρεάσουν τη σταθερότητα του πλοίου, την ακεραιότητα του φορτίου και την ασφάλεια του πληρώματος. Επιπλέον, εξετάζει τη σημασία της ολοκληρωμένης εκπαίδευσης των μελών πληρώματος, ώστε να μπορούν να χειρίζονται αποτελεσματικά τα χύδην φορτία και να ανταποκρίνονται σε πιθανές καταστάσεις έκτακτης ανάγκης.

Μέσω συνεντεύξεων με έμπειρους πρώην ναυτικούς, η έρευνα παρέχει πολύτιμες γνώσεις για τις πρακτικές και τις προκλήσεις της βιομηχανίας. Τα ευρήματα υπογραμμίζουν την ανάγκη για συνεχή βελτίωση στα πρωτόκολλα ασφαλείας, τις τεχνολογικές εξελίξεις και τα ρυθμιστικά πλαίσια για την ενίσχυση της ασφάλειας των λειτουργιών των πλοίων μεταφοράς χύδην φορτίου.

Λέξεις - κλειδιά: φορτηγά πλοία, ασφαλής μεταφορά, παρακολούθηση φορτίου, πρωτόκολλα ασφαλείας, διαχείριση κινδύνων, ναυτιλιακή βιομηχανία.

1. Introduction

Bulk carrier industry

A bulk carrier vessel specifically built to carry unpackaged bulk goods, such as grain, coal, ore, steel coils, and cement, in its cargo holds is known as a bulk carrier or bulker. Since the construction of the first specialized bulk carrier in 1852, economic factors have caused these vessels to grow in size and sophistication. Bulk carriers of today are built with specific features to increase capacity, durability, safety, and efficiency.

Bulk carriers, which range in size from single-hold mini-bulk carriers to enormous ore ships capable of carrying 400,000 metric tons of deadweight (DWT), currently comprise 21% of the world's maritime fleets. There are several specialized designs available; some can load their own cargo, some rely on port facilities for offloading, and some are capable of unloading the cargo themselves. More than 25% of bulk ships are registered in Panama, and more than half of them have Greek, Japanese, or Chinese owners. Eighty-two percent of the ships produced were constructed in Asia and some of them in South Korea, the world's largest single bulk carrier builder, .

In compliance with international maritime law, crews on bulk carriers operate, manage, and maintain the ship, attending to safety, navigation, maintenance, and cargo handling. On the smallest ships, crews can consist of three persons, while on the largest, they can number over thirty.

Thesis aims and objectives

Fundamental purpose of this essay is to analyze and give prominence to the absolutely necessary requirements and procedures that strictly need to be followed in accordance with the regulatory framework that has been created by the International Maritime Solid Bulk Cargoes (IMSBC) Code.

The code itself incorporates proposals to Governments, dispatch administrators and shipmasters. Its point is to bring to the consideration of those concerned an internationally-accepted strategy of managing with the dangers to security which may be experienced when carrying cargo in bulk. It highlights the risks related with the shipment of certain sorts of bulk cargoes, gives direction on different strategies which ought to be received, records commonplace cargoes which are transported in bulk, gives exhortation on their properties and how they ought to be taken care of and depicts different test methods which ought to be utilized to decide the characteristic cargo properties.

Following the same track, will endeavor to point out the most critical stages of the most commonly transported bulk cargoes and provide guidelines for each step of the voyage (loading, laden leg and discharging) that foster the safety of the crew, cargo, vessel and environment. The whole analysis can itself constitute a helpful guidance for both ship and shore personnel, as liability for successful transportation of cargo is shared between the two parties.

Some of the main hazards that come with carriage of bulk cargoes and need to be faced are liquefaction, cargo shift, structural damage, fire, explosion, cargo damage/loss etc. Identifying and deeply understanding over the years which of the beforementioned are applicable to each different cargo, allows us to provide guidance and expert advice according to the cargo's unique characteristics.

The significance of regulatory framework

The International Maritime Organization (IMO) started creating a globally recognized code of safe practice in 1960 in order to solve the issues associated with the shipping of bulk cargoes. This evolved into the Code of Safe Practice for Solid Bulk Cargoes (BC Code), which has been published in multiple editions since its initial release in 1965. The International Maritime Solid Bulk Cargoes (IMSBC) Code replaced the BC Code in 2008, and it was decided that updates would be made to the code on a regular basis. All solid bulk commodities are covered by the IMSBC Code, with the exception of grain, which is covered by the International Code for the Safe Carriage of Grain in Bulk (International Grain Code), 1991.

The necessary regulations controlling the transportation of solid bulk cargoes are found in chapter VI of the International Convention for the Safety of Life at Sea, 1974 (SOLAS Convention), as modified. The Convention addresses a number of marine safety issues. The International Maritime Solid Bulk Cargoes Code (IMSBC Code) expands upon these requirements. It was created with the primary goal of facilitating the safe stowage and shipment of solid bulk cargoes. To this end, it offers guidance on the protocols that should be followed when shipping certain types of solid bulk cargoes, as well as information on the risks involved in doing so.

The main risks involved in shipping solid bulk loads are those related to structural damage from incorrect cargo distribution, loss or decrease in stability while in transit, and cargo chemical reactions. As a result, the main goal of the IMSBC Code is to make it easier for solid bulk cargoes to be stowed and shipped safely by supplying information on the risks involved in shipping specific kinds of solid bulk cargoes as well as guidelines for the steps to take when shipping solid bulk cargoes. When solid bulk commodities are transported by sea, adherence to the Code unifies the practices and processes that must be followed as well as the necessary safety measures to be taken during loading, trimming, transportation, and discharge. This ensures compliance with the mandatory provisions of the SOLAS Convention.

Taking all the above into consideration, this research aims to combine the theoretical background with actual cases and experience and provide clear answers regarding safety concerns in bulk cargo operations, examine the hazards of multiple cargoes and how can be avoided at all steps of the voyage. Coordination between the crew and shore-based personnel will be also analyzed, defining each role and pointing out their significance in the transportation process.

2.1 Problem statement

Unfortunately, over the last decades, there have been several accidents in the industry and there are several factors that played crucial role. Despite hundred years of experience and existing regulations, there may be inconsistencies or gaps in safety protocols for bulk carrier transportation, leading to increased risks.

Deep understanding of cargoes' characteristics and nature is required, as each one demands unsimilar handling and care, which in case of failure can pose various threats to the safety of a vessel and its crew. All hazards need to be carefully studied and proper procedures for cargo handling, stowage, ventilation, and emergency response shall be taken for each part of the voyage. Thankfully, in bulk carrier industry the environmental and sea pollution threats due to cargo spoilage are not observed.

Additionally, in spite of technological growth, which has resulted to safer cargo transportation, human being has always been in charge and has fundamental role in every aspect of the dry bulk operations. Mistakes, oversights, or negligence by crew members can contribute to accidents. Inadequate training or a lack of competence among crew members can lead to decisions made by ship officers, including those related to navigation, cargo handling, and emergency response, can have a critical impact on safety. One of the reasons why crew welfare is in the center of attention from marine institutions is because long working hours, fatigue, and stress can impair a crew member's judgment and increase the risk of errors.

Addressing above challenges requires a comprehensive approach that involves continuous improvement in safety protocols, technological advancements, and enhanced training and education for crew members.

2.2 Presentation of research questions

Despite the fact that the analysis provided in this essay refers to multiple common issues of the bulk carrier industry, it is endeavored to preserve the interest of the discussion and provide solid answers to the three following questions:

1) Which are the main hazards (fire, explosion, liquefaction etc.) of the most commonly transported bulk cargoes?
2) How can the abovementioned hazards be avoided from the time of loading on board until the moment it gets fully discharged?

3) Which cargo related procedures are strictly followed on board in order to ensure crew, vessel and environmental safety and which is the role of the shore-based office personnel?

3.1. Methodology

In order to support the provided information and research, it was found prudent to contact a detailed interview of an ex-Bulk Carrier Master, who has recently been transited ashore and offers his assistance through his vast experience at this new role.

A semi-structured interview with an ex-Mariner of bulk carrier industry serves best the scope of this analysis, as his lifetime service on board makes him suitable to combine the theoretical approach with the hands-on experience. It is of great interest and can be deemed an asset to hear an expert's opinion, which will assist in better understanding of the theoretical discussion and will support the cited arguments. It is believed that by incorporating insights from a bulk carrier master, credibility and relevance of the whole research is enhanced. For the same reason, it is customary for ex Masters to join the office of a shipping company as shore personnel when permanently leaving the sea. They have a thorough awareness of the difficulties, and best practices of the field. Having this knowledge can be very helpful when making decisions, solving problems, and advising colleagues. Their first-hand knowledge of numerous aspects of bulk cargo operations, including crew management, safety protocols, and cargo handling, can provide an original viewpoint on tasks that are performed in offices. Overall, an ex-bulk carrier master can bring a wealth of knowledge, skills, and experience to an office environment, making them a valuable asset to any shipping organization.

3.2 Results and discussion

Interviewing an ex-Mariner, Bulk Carrier Master and hear more about marine industry from his standpoint is invaluable, as he can offer firsthand insights into the practical challenges and best practices within the industry. Their experiences can provide a rich source of qualitative data to support theoretical concepts or research questions. The interview provides valuable insights into the day-to-day operations of bulk cargo carriage. This includes information on cargo handling procedures, safety measures, crew management, and environmental practices.

Based on the interview, the following are the most commonly mentioned hazards associated with bulk cargo transportation:

1) Liquefaction - This is a significant risk for certain types of cargoes, especially grains and ores. When these cargoes become moist, they can liquefy, leading to loss of stability and potential capsizing. 2) Fire and explosion: Some bulk cargoes, particularly those with flammable properties, pose a fire and explosion risk. This can be exacerbated by improper handling or storage. 3) Stability issues: Improper loading, stowage, or ballast management can lead to stability problems, increasing the risk of capsizing.

All of the above are also mentioned in the bibliography and concern most of the commonly carried cargoes, which will be further analyzed as part of this discussion.

The interviewee highlights several strategies for preventing these hazards, as proper handling of the cargo, which shall be based to established procedures for loading, stowage, and unloading helps prevent stability issues and cargo damage.

Furthermore, regular stability calculations and assessments are crucial to ensure the vessel remains stable throughout the voyage. Conducting regular risk assessments are highly recommended in modern shipping as they help identifying potential hazards and implement preventive measures.

Additionally:

- well-trained crew members are better equipped to handle cargo safely and respond to emergencies.
- Regular maintenance of equipment, such as winches and cranes, helps prevent breakdowns and accidents.
- Having emergency plans in place according to the company's SMS and ensuring crew members are trained on how to respond to emergencies can help mitigate the impact of accidents.

In respect of cargo-related procedures and as we heard from the interviewee, adherence to IMO and international regulations, such as SOLAS and MARPOL, is essential for maintaining safety standards. Additionally, creating a strong safety culture within the organization is crucial for promoting safe practices among seafarers and implementing measures like personal protective equipment, safe working practices, and crew training helps protect crew members during cargo handling operations.

Finally, the shore office plays a vital role in coordinating various aspects of the voyage, from booking berths to providing technical support and handling emergencies. By following these procedures and maintaining a strong safety culture, both seafarers and shore-based personnel can contribute to the safe and efficient transportation of bulk cargoes.

4.1 Carriage of Coal Cargo – Loading and monitoring

Transported in vast quantities throughout the world, coal is a chemical raw material and an essential energy source. Over a billion tonnes of coal are transported by sea each year. However, transporting coal as a cargo entails a number of risks, so it must be done so in compliance with the pertinent legal requirements, which are listed below.

Coal is a term that refers to a relatively broad range of cargoes, given its origins as a carbonaceous sedimentary rock formed over time by geological processes applying pressure to the remnants of plant material. Coal comes in many different forms. Certain safety measures must be taken when loading coal cargoes and during the voyage. When it comes to coal transportation at sea, the following features are the most important and must be taken into account {Britannia P&I Club (2021, February)}.

Some coals may:

- emit methane (CH_4), which in turn may potentially create a flammable or explosive atmosphere susceptible to ignition by a spark or flame. CH_4 will accumulate in the upper layer of a space and can also leak into adjacent areas if the cargo space is not gas tight
- deplete oxygen (O_2) in cargo holds and adjacent spaces, leading to an increase in carbon dioxide (CO_2) in the cargo space
- be prone to self-heating and potentially spontaneous combustion resulting in the release of carbon monoxide (CO) – an odourless, but toxic gas if inhaled, and with flammable limits in air of 12% to 75% by volume
- liquefy, if carried with excessive moisture content (as detailed further below);
- react with water, producing corrosion-inducing acids, as well as toxic gases and hydrogen (H), which is lighter than air and odourless with flammable limits in air of 4% to 75% by volume.

Regulatory requirements

Coal must always be loaded, transported, and released in compliance with the International Maritime Solid Bulk Cargoes (IMSBC) Code since it is a potentially dangerous bulk cargo. In addition to providing information on the associated risks, such as asphyxiation and crew member exposure to toxic gases, the IMSBC Code includes a comprehensive schedule for the carriage of coal and lists the safety measures that must be followed. Both shore and ship management should be aware of and strictly adhere to these requirements.

IMSBC Classification

Coal is classed as IMSBC **Group A and B**, which are defined as follows:

- **Group A**: Cargo which may liquefy if shipped at a moisture content in excess of the transportable moisture limit (TML)

- **Group B**: Cargo which possesses chemical hazards

Coal can be classed as **Group B** (only) in one of the following cases:

- By a test determined by the competent authority in the country of origin, or
- When the particle size distribution fulfils specific criteria defined in the IMSBC Code.

It should be noted that blended coals should be considered as both Group A and B, unless all the original coals are Group B only.

<u>IMSBC Group A Liquefaction Hazard</u>

Except for coal cargoes classified as Group B only, the cargo declaration must be accompanied by documentation from an organization recognized by the port of loading's competent authority that pertains to the cargo's moisture content (MC) and TML. For specific requirements in this regard, one should refer to section 4 of the IMSBC Code. These requirements include:

- The TML certificate should contain or be accompanied by the testing done for determination of TML. The shipper is responsible for ensuring that a test to determine the TML is conducted within six months of the date of commencement of cargo loading.
- Additionally, the shipper bears the responsibility of making sure that the MC's sampling and testing are carried out as close as possible to the loading date. There should never be a longer than seven days between the date of sampling/testing and the start of loading.
- The MC certificate should be accompanied by a statement by the shipper that the MC is, to the best of their knowledge and belief, the *average* moisture content of the cargo at the time of declaration.
- A document certifying that the shipper's procedures for sampling, testing, and controlling the MC of cargo on board (to make sure that the MC is less than its TML) are approved and the implementation checked in accordance with section 4.3.3 of the IMSBC Code should be given to the ship's master by the competent authority at the port of loading.

According to the IMSBC Code, the shipper must make sure that the cargo's MC remains less than its TML if there has been a lot of rain or snow between the time of testing and the date that loading is completed. They must also make sure that the ship's Master receives proof of this as soon as is reasonably possible.

When creating the procedures under 4.3.3 (above), the shipper must incorporate measures to safeguard the cargo on the barges from any precipitation and water intrusion if the cargo is loaded onto the ship from barges.

Cargo declaration

Shipowners should confirm for themselves that the shipper has complied with the IMSBC Code's requirements regarding the cargo properties and related hazards, especially with regard to the cargo declaration. A section of the declaration must expressly state whether the coal cargo has the potential to self-heat or release methane. The IMSBC Code's Special Precautions for "coals emitting methane" and "self-heating coals," respectively, must be followed in such cases.

The IMSBC Code also stipulates that the shipper shall provide the Master with the characteristics and the recommended safe handling procedures for the loading and transport of the coal cargo. As a minimum, this information should include the cargo’s contract specifications for moisture content, sulphur content and size.

Cargo temperature upon loading

According to the IMSBC Code, temperature measurements of the cargo must be made both prior to and during loading if it is determined that it is susceptible to self-heating. However, it is advised that the temperature of the coal be checked before loading in every situation because the cargo declaration might be off. Before the cargo is transferred to the vessel, surveyors may need to be hired in order to get sufficient measurements, depending on local logistics and the stockpile's location. It is important to take careful measurements because you might need them as proof if the loading is stopped or the cargo is refused.

Temperatures above 55°C for coal cargoes will not be permitted for loading. The limit is in place because, once inside the cargo hold, the rate of the self-heating reaction is likely to reach a temperature where it will self-ignition before the reaction can be slowed down by limited oxygen levels.

<u>Temperature measurements</u>

The IMSBC Code recommends that instruments available on board enable cargo temperature measurements in the range from 0°C to 100°C.

It is most likely that localized areas within the cargo mass will experience self-heating. If installed, temperature sounding pipes and sensors are typically found close to the bulkhead, meaning they are outside of the stow. It is important to remember that the readings taken here only reflect the temperature close to the pipeline. Coal has the ability to insulate heat, so it's possible that this method won't reveal a localized rise in the stow's temperature. As a result, temperature readings by themselves might not be a trustworthy sign of self-heating.

However, as the self-heating of coal results in the emission of carbon monoxide (CO), measurements of gas concentrations are considered a more effective method of monitoring for self-heating, as detailed below.

<u>Gas measurements</u>

Measuring gas concentrations should reveal the two main risks connected to coal transportation: self-heating (indicated by CO concentration) and explosive atmospheres (indicated by methane (CH_4) levels).

It is mandatory for all vessels involved in coal transportation to possess suitable gas monitoring apparatuses capable of detecting levels of CO, O_2, and CH_4. Sampling points are used to access headspace in cargo holds. Before taking the measurements, ventilation should be stopped for a sufficient amount of time (at least four hours) if the holds are being ventilated. Complete, in-depth instructions on sampling and measurement techniques are provided by the IMSBC Code.

This covers sampling point placement as well as a measurement plan for holds with and without ventilation. When interpreting CH4 measurements obtained in low oxygen environments, caution should be used. This is due to the fact that adequate O2 levels are necessary for the catalytic sensors that are typically used to detect CH4. Nevertheless, this has no bearing on CO readings or infrared sensor measurements of CH4. The manufacturer of the instrument can provide more advice.

Verify that the sampling ports and gas (and temperature) monitoring apparatus are in good operating order prior to loading. All of this equipment needs to be routinely serviced and calibrated. The people performing these inspections ought to be suitably trained and informed of the limitations of the equipment, such as the fact that methane measurements made in environments with low oxygen concentrations will be less precise.

Ventilation

Gas concentration measurements should provide an indication of the two major hazards associated with the carriage of coal, i.e. self-heating (reflected by CO concentration) and explosive atmosphere (reflected by methane (CH_4) levels).

It is mandatory for all vessels involved in coal transportation to possess suitable gas monitoring apparatuses capable of detecting levels of CO, O2, and CH4. Sampling points are used to access headspace in cargo holds. Before taking the measurements, ventilation should be stopped for a sufficient amount of time (at least four hours) if the holds are being ventilated. Complete, in-depth instructions on sampling and measurement techniques are provided by the IMSBC Code. This covers sampling point placement as well as a measurement plan for holds with and without ventilation.

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Bilge water measurements

Hold bilge It is advisable to conduct routine pH testing while on the journey. In order to prevent potential acid buildup on tank tops and in the bilge system, the bilges should be regularly pumped out during the laden voyage.

Incidents correlated to coal carriage

1) When this bulk carrier reached her UK discharge port on September 14, 2005, a smouldering coal cargo fire was found in multiple holds {GOV.UK, 2015}. Fortunately, there were no losses or injuries to the crew or stevedores, and the fire was put out without causing any material damage to the ship.

The manager of the ship was advised to review the Safe Carriage of Coal procedure in their Safety Management System and enhance senior officers' knowledge and training regarding the transportation of coal cargoes in order to avoid a recurrence of the same accident. In addition to requiring the master and chief mate to apply the pertinent sections of the BC Code, the procedure should address the risk of fire.

2) There was a coal-carrying anchored bulk carrier {Marine Insight, Real Life Incident, 2024}. The deck crew had to grease the dog handles on the hold access booby hatch. Some of the handles were rusted and had to be disassembled before they could be greased. Four crewmen were trying to free the dog handles at one of the booby hatches. A disassembled dog handle fell down the booby hatch, which was open while they were doing this. One man came down to retrieve it. As he climbed back up using the dog handle he had recovered, he fell and landed on the coal cargo about 3.5 meters below the surface, losing consciousness from oxygen deprivation.
The crew quickly mobilized to rescue the victim after the alarm was sounded. After arriving at the booby hatch with an Emergency Escape Breathing Device (EEBD) hood, an officer used the booby hatch ladder to enter the cargo hold. In the meantime, an effort was being made to supply air to the hold by connecting two air hoses to the air supply. The officer who had used the EEBD to enter the booby hatch quickly emerged and reported that the cargo hold was hot and difficult to breathe.

The head chef then made the independent decision to take charge of the situation. He grabbed the safety harness, ropes, and two air hoses in an effort to save himself. Within five minutes, the cook had the safety harness under the victim's arms, and the main deck crew had successfully taken him out. The cook left the hold shortly after. The victim was not breathing, and there was no heartbeat or pulse. Following CPR, the victim was taken ashore, where it was discovered that he had died.

Learned from incident

In an emergency rescue, the atmosphere of an enclosed space should always be considered dangerous until proven otherwise. Using an EEBD to rescue a victim in a closed area is never appropriate. Furthermore, this equipment is only meant to be used for escape from a compartment with a hazardous atmosphere; it should not be used to enter oxygen-deficient areas or tanks on a ship. Several closed-space incidents have led to further deaths; rescuers attempting to save the main victim have themselves died from oxygen deprivation in poorly planned and executed rescues. In this case, the EEBD officer and the cook were just "lucky."

4.2 Carriage of grain cargo – Preparation, loading and monitoring

Bulk grain and oilseed cargo loading, transporting, and unloading present a number of difficulties. The primary factors to take into account when transporting bulk grains and oilseeds are outlined in this advice {The Swedish club, Grain and oilseed cargo advise}. The master of a ship obliged to carry grain has concerns regarding grain stability that are not applicable to most other bulk cargoes. In compliance with the IMO Grain Rules, he must arrange a cargo distribution that meets the strict stability requirements, make sure the cargo is loaded, stowed, and, if needed, secured, and satisfactorily complete the related paperwork.

The hatch covers, holds, and bilges must be completely clean, dry, and free of any infestations or taint before grain is carried. Since the cargo is intended for human or animal consumption and needs to be kept clean, it is reasonable to refuse loading grains onto a ship if the cargo spaces are not completely clean. Furthermore, it has frequently been proposed that the surveyors examine the ship even more thoroughly than usual if there is no cargo ready for loading in order to find a reason to reject her and postpone the start of laytime. The ship must make sure that the surveyors have no good reason to reject the vessel. All hatch covers, coamings, beam flanges, frames, brackets, casings, manhole covers, and bilge wells must be free of any remnants of prior cargoes and loose scale. If the surveyor requests it, bilge wells should be easily accessible for preloading inspection and bilge suction testing. A few hours prior to the preloading inspection, the master or chief mate should recheck the cargo spaces to make sure everything is in working order.

It is advisable to conduct a hatch cover test before loading. Hose testing or an ultrasonic device can be used for this. These tests are crucial because they allow the crew to fix any hatch cover issues before loading the cargo. In the event of a wet damage cargo claim, it also offers strong evidence to refute claims of water intrusion through the hatch covers.

Throughout the loading process, it is important to periodically check the state of the cargo. Although it is unrealistic to expect ship officers to be experts in grain condition, they should be able to identify bad grain by looking for signs such as wetness, sprouting, mold, discoloration, or contamination from dead or living insects or rat droppings. While it is not possible to see every grain that is loaded, one can get a good idea of its general condition by looking through cargo that is spilled on deck, cargo in the holds during loading pauses, and cargo inside the hatch coaming during the last stages of loading each hold. Additionally, depending on how the grain is delivered alongside, it might be able to be inspected ashore prior to loading. If grain seems unfit for shipping, it should be refused completely. If charterers insist on the shipment, surveyors working on behalf of the owners should conduct the survey and record any objections right away.

Fumigation of cargo

Following loading, cargoes containing grains and oilseeds are typically fumigated. Usually, the fumigation is done while the cargo is in transit, but occasionally it can be done on land before loading or when it gets to the destination. The Master should also be given the necessary safety gear and instructions regarding crew safety during fumigation in addition to this information. This ought to cover the necessary ventilation to guarantee that the holds are free of gas. When fumigating bulk grain and oilseed cargoes, methyl bromide and aluminum phosphide are the two fumigants that are most frequently used.

The typical exposure time for phosphine fumigation, during which the holds have to be kept sealed, is not set and can range from 3.5 to 18 days. For bulk grain, the typical fumigation exposure duration is ten days. The Master may be advised not to ventilate the hold for a considerable amount of time, sometimes even for the duration of the voyage (especially if grains are loaded and fumigated in the USA). It is advised that owners get in touch with their charterer right away if this is the case, since a lengthy fumigation exposure period may not account for changes in the environment that could cause condensation and damage to the cargo's surface. To guarantee that any leftover fumigant gas is dispersed, the holds should be ventilated in compliance with the fumigation instructions after the fumigation exposure period has ended. Prior to discharge, it is highly advised that a fumigation company be hired to check the fumigant gas levels and provide a Gas Free Certificate. When a cargo hold has not been verified as gas-free and secure to enter following fumigation, personnel should never enter it.

Risks during laden voyage

1) Condensation - ship’s sweat and cargo sweat

When the vessel's steelwork is colder than the headspace air's dew point, ship sweat forms. This usually happens when a ship sails into a colder climate and the steelwork cools due to the decreased outside air temperature. Because of this, the water vapor in the hold headspace condenses onto the steelwork, drips onto the cargo surface, and eventually runs down the hold's frames. This damage is characterized by wetting and related mold damage, which is evident across the cargo's surface as a recurring pattern that reflects the hatch cover frames directly above. Damage that extends further into the stow may arise from repeated wetting brought on by the long-term buildup of ship sweat. Ship sweat occurs when the steelwork of the vessel is colder than the dew point of the headspace air. This typically occurs when a ship enters a colder region and the steelwork cools as a result of the drop in air temperature outside. As a result, water vapor in the headspace of the hold condenses onto the steelwork, drips onto the cargo surface, and ultimately cascades down the frames of the hold. Wetting and associated mold damage characterize this damage, which is visible throughout the cargo's surface as a repeating pattern that mirrors the hatch cover frames directly above. Ship sweat builds up over time, causing recurrent wetting that can cause damage further into the stow. Periodic ventilation of the holds with air much colder than the cargo temperature can also occasionally result in cargo sweat. As a result, the immediate surface layer's cargo temperature may drop. Moisture from the majority of the stow may rise and condense against the cooled cargo at the surface if there is a subsequent delay in discharge.

2) Water ingress

When water seeps through hatch covers, it usually manifests as visible mold-damaged columns and grain-caked pillars where the water directly leaked from the point of entry.

- Making sure that all hatch covers and manhole covers are routinely inspected to guarantee water tightness is the only preventive measure. It is important to routinely inspect and maintain the rubber hatch cover seals and steel compression bars. As was already mentioned, the crew needs to make sure that an ultrasound or hose test is done before the trip.
- Severe weather during the journey may also cause seawater to enter through open ventilation windows or hatch covers. Upon reaching the destination, a sea protest detailing the weather event should be issued.
- Mould and wet damage at the lower part of the hold are often attributed to overflowing and poorly maintained bilges. A surveyor or crew member should closely inspect the condition of the bilges prior to loading cargo to ensure that wastewater can be easily removed.
- In order to prevent the bilges from overflowing, it is also important to measure and record the bilge levels on a regular basis during the voyage and to pump out water as needed. After every hold has been emptied, the bilges ought to be examined for any indications of water buildup.

3) Self-heating

Bulk loads of wholegrains and oilseeds, such as wheat, barley, and soy beans, continue to go through biological processes while being stored. The grains keep on their slow respiration, burning oxygen and producing heat, carbon dioxide, and water. The temperature of grains and oilseeds can gradually rise over time due to the volume of cargo in the holds and their high capacity for insulation. Thankfully, the rate of respiration is extremely low when carrying cereal grains, so the temperature rise is typically negligible. While being stored, bulk loads of wholegrains and oilseeds, including wheat, barley, and soy beans, continue to undergo biological processes. The slow respiration of the grains continues to produce heat, carbon dioxide, and water as they burn oxygen. Grain and oilseed temperatures can rise gradually over time because of the volume of cargo in the holds and their high insulation value. Fortunately, carrying cereal grains causes very little respiration, so the temperature rise is usually minimal.

There is an added risk of self-heating from oil breakdown when transporting loads with a high oil content or processed feed products with residual oil content. Because of this, cargoes containing oilseeds and seed cakes are more likely to self-heat than cargoes containing cereal grains. Long-term storage of such cargoes on board can result in temperatures rising above 50 °C. When a product is heated excessively, it may become severely discolored and carbonized. The process of self-heating can also be started by a variety of other possible heat sources. Insect infestation is a common source of heat. Similar to other living things, insects produce heat as a byproduct of their metabolism. An extensive insect infestation may cause cargo damage and a sharp rise in temperature. It should be mentioned that contamination and physical harm to the grain are also consequences of insect infestation. Cargo lights, poorly installed fumigant recirculation fans inside the hold, and heated FOTs next to the holds are a few more external heat sources. The process of self-heating can be started by the localized heating produced by these external heat sources. There isn't much that can be done to halt the temperature from rising further in the case of self-heating. The purpose of ventilation is solely to eliminate warm, humid air from the headspace; it has no effect on the cargo's internal temperature. The only way to reduce self-heating that is really effective is to release the cargo as soon as you can. After discharge, self-heating might persist if the cargo is kept in big piles with inadequate airflow.

Incidents correlated to carriage of grains

The soybean meal suffered severe heat damage as a result of the heating of the aft double bottom fuel oil tank beneath the cargo hold. Due to space constraints, the chief officer chose to load the package in hold number seven after the ship received last-minute instructions from the charterer to arrange for the loading of soybean meal. The cargo hold is located in front of the bulkhead of the engine room, directly above the fuel oil tank. In order to disperse excess heat energy, the exhaust gas economizer's (EGE) continuous heat was also recycled back into the fuel oil tanks. The ship's crew member did not monitor the temperature of the fuel oil tank heating throughout the voyage even though the tanks were fitted with temperature sensors.

Approximately 3,500 metric tons of cargo were allegedly rejected by the receiver after being discovered to be damaged by heat upon discharge {Britannia P&I Club, Case study, 2023}. The estimated value of the claim was a quarter of a million dollars. During the fuel transfer process, the temperature of the service and settling tanks can rise to over 80°C. This implies that if the bulkhead in the engine room is not adequately insulated, the cargo hold located in front of it will be subject to heat radiation. Cofferdams and insulation between the engine room and the bulkhead of the cargo hold are features of some contemporary ships. Therefore, ships without this design should prioritize loading non-agricultural products in this after hold and/or plan their stowage of valuable but vulnerable cargo with this consideration in mind. Crew members failed to keep any temperature records of the cargo holds or the heating of the fuel oil tank, according to certain post-event investigations. When defending claims against the vessel's owners, this might work against you.

4.3 Carriage of Iron Ore

Iron Ore fines

Iron ore fines are defined by the IMSBC Code as cargo with a maximum size range of 250 mm, 10% or more fine particles of less than 1 mm, and 50% or more of particles of less than 10 mm. Iron ore has a lower moisture content than other materials, and moisture contents quoted for iron ore fines usually range from 6 to 12%.

The Association has been involved in incidents that have brought to light a variety of operational issues that may occur when loading a cargo of iron ore fines. We'll talk about liquefaction, the usual issues it causes, and preventative measures for these issues below.

Liquefaction

The voids between the cargo grains in fine-grained, moisture-laden cargo are full of both water and air. When the ship is at sea, its rolling and vibrations exert forces on the cargo. The intergrain spaces contract as a result of these forces. Although the water in the voids between the grains is subject to compression, it cannot be compressed because it is a liquid. The cargo is held in a solid state by the intergrain frictional force being reduced as a result. When there is adequate moisture present, the ship's motion and vibration can reduce intergrain friction to the point where the cargo liquefies and flows like a liquid.

The biggest effect that liquefaction has on a vessel is a shift in cargo that causes instability {North of England P&I, Iron Ore Fines (2017, March)}. This could result in hazardous list angles, and in certain cases the ensuing loss of stability could be catastrophic enough to destroy the ship and all people on board. Seafarers must therefore be fully informed about the kinds and conditions of cargo that can result in liquefaction.

The International Maritime Solid Bulk Cargoes (IMSBC) Code is the primary source of information that ship operators and masters should consult when determining whether a cargo has the potential to liquefy. The Code enumerates the risks connected with frequently transported cargoes; group A cargoes are those that are prone to liquefy. Group A cargo must be transported strictly in compliance with the IMSBC Code's regulations.

Section 1.2.1 of the Code itself, however, cautions that the schedules for specific cargoes are not all-inclusive. In the event that a cargo does not appear in the IMSBC Code as a "Group A" cargo, ship operators and masters should not automatically assume there is no risk of liquefaction. If a cargo is not specified in the Code, it should only be loaded after the Competent Authority has issued the necessary certificate, as stipulated in Section 1.3. Any bulk cargo with the right amount of moisture and fine particles in it has the potential to liquefy. Ship operators and masters must be conversant with every section of the IMSBC Code.

Shipper's obligations

SOLAS is clear that the shipper must give the master or his representative the relevant cargo information well enough in advance of loading to allow the implementation of the necessary safety precautions for cargoes with special hazards, like liquefaction. Additionally, the format for this type of information is provided in IMO circular MSC/Circ.663. Furthermore, certain provisions require additional information to be provided in the form of a transportable moisture limit (TML) and certificate of moisture content for cargoes that have the potential to liquefy. As a result, before loading starts, shippers are required to give the master the necessary cargo information.

Master's and Terminal's duties

"Concentrates or other cargoes which may liquefy shall only be accepted for loading when the actual moisture content of the cargo is less than its TML," according to SOLAS, Chapter VI Part B, Regulation 6.2. Consequently, if the moisture content of the cargo is demonstrated to be lower than the TML, the master should not accept the cargo for loading without first obtaining the necessary paperwork verifying the moisture content and TML of the cargo.

When terminal agents put commercial pressure on shippers to load their vessels prior to receiving the cargo declaration from shippers, they are breaking SOLAS and the BLU Code. It is recommended that masters buck these pressures. The master is in charge of making sure the ship is loaded safely; if the shipper's cargo declaration is missing, the master is unable to determine the likely characteristics of the cargo that needs to be loaded. A master should not start loading and should notify owners right away if such a declaration is not forthcoming. In such cases, members should get advice from the Association.

Shipper's declaration

This documentation should be sent to the vessel well in advance of loading, and masters should rebuff pressure from shipper or terminal representatives to start loading before the certificate is received. Delaying loading until after the certificate is received is preferable to having to release improperly loaded cargo before the certificate is received. A discharge of this kind could be extremely problematic because of inadequate gear, berths, local customs, or other rules. Shippers and terminals might merely refuse to accept the released cargo. A signed certificate specifying the cargo's moisture content and TML should be included with the shipper's cargo declaration. In addition Section 4.3.2 states that ‘the certificate of TML shall contain, or be accompanied by, the result of the test for determining the TML’.

The ship's masters should resist pressure from shipper or terminal representatives to begin loading before the certificate is received, and this documentation should be sent to the vessel well in advance of loading. It is better to wait to load until after the certificate is obtained rather than having to release cargo that was incorrectly loaded before the certificate is obtained. Such a discharge could present significant challenges due to insufficient equipment, cramped quarters, regional regulations, or other factors. It is possible for shippers and terminals to simply decline to accept the released cargo. Together with the shipper's cargo declaration, there should be a signed certificate stating the moisture content and TML of the cargo. Therefore, masters and their officers are always required to be on the lookout for the condition of the cargo as it comes onboard, even in cases where the certificate indicates that the cargo is safe to load. Because various cargo stockpiles may exhibit disparate qualities, caution must be exercised throughout the loading process.

There have been cases where the TML and moisture content certificates are present but do not seem to match the characteristics of the cargo presented for loading, where the shipper's cargo declaration is not presented prior to loading, and where the TML and moisture content certificates are included but not with the declaration.

- Loading should not commence until the shipper’s cargo declaration is received.
- The moisture content, TML, and FMP of the cargo to be loaded, if applicable, must all be included in the cargo declaration. The documentation must include both the moisture content and the TML, as it is impossible to assess whether the cargo is suitable for transportation without both numbers.
- Since weather conditions can significantly alter the moisture content of cargo, the certificate should not be older than seven days. In cases where there has been substantial precipitation or

snowfall between the testing and loading dates, follow-up tests must be carried out to confirm that the cargo's moisture content remains below TML. (even if this means testing must take place one day after the previous test).

• Where the declaration is not received or where both the moisture content and TML are not included in the certification the master should refuse to loa

Flow moisture point (FMP) and Transportable Moisture Limit (TML)

The highest water content, given as a percentage, at which a cargo sample will start to lose shear strength is known as the "Flow Moisture Point." Over FMP moisture content in cargo may cause it to liquefy. When the Flow Table Test (FTT) and Penetration Test are performed in tandem, the Transportable Moisture Limit is defined as 90% of the FMP. The TML of iron ore fines can be ascertained using the modified Proctor Fagerberg test method.

From the viewpoint of the ship operators and master, the TML and actual moisture content of a representative sample of the cargo to be loaded are crucial parameters for the laboratory to ascertain. The average moisture content of any kind of granular cargo in any cargo space cannot be higher than the TML per the International Convention for the Safety of Life at Sea (SOLAS). The laboratory must first use one of the recommended techniques to determine the sample's FMP in order to find the TML.

Can test

Section 8 of the IMSBC Code describes a shipboard technique known as the "can test" so that the vessel can determine the likelihood of the cargo to liquefy on its own. To do this, fill a small can with the substance and pound it against a hard surface several times. An assessment of the material's suitability for shipment can be made based on how it looks at the conclusion of the test. This test should not be used in place of appropriate laboratory testing with the right methodology. On the other hand, if tests on a cargo that is being loaded show a tendency for liquefaction, this is a serious red flag that the cargo might not be safe to transport in its entirety. The next step would be to consult an expert. Shippers should be aware that if they present large quantities of material that fails the can test (see picture of an iron ore fines cargo that failed the test), the cargo may not be safe overall and any certification to the contrary may be faulty. Remember that a negative can test result (i.e., no visible free moisture or fluid condition) does not always imply that the cargo is safe for shipping.

Accidents correlated to iron ore carriage

In March 2017, the Marshall Islands-flagged very large ore carrier (VLOC) was underway in South Atlantic Ocean, carrying 260,003 tons of iron ore cargo from the Vale Ilha Guaiba terminal near Rio de Janeiro, Brazil, to China, when it went missing on 31st March 2017 {Safety4sea, Learn from the past: Stellar Daisy sinking, 2019}.

At that day, a crew member sent a text message to their South Korean employer, Polaris Shipping, informing that the ship was taking on water. Radio contact with the ship was lost, about 1,300 nautical miles off Uruguay. A total of 24 crew members were onboard at that time.

A coordinated research with eight ships and two aircrafts by Maritime Rescue Coordination Center (MRCC) of Uruguay, an aircraft and merchant ships coming from America, as well as Brazilian Air Forces and Brazilian and Argentine search vessels were searching the vessel for days. Two crewmen were found on a life-raft shortly after and were rescued by a cargo ship nearby. Hopes for survivors started fading, as the crew reported that they had seen their ship sinking. The search operation had no result until mid-February 2019. Almost two years after the tragedy, the American ocean exploration company Ocean Infinity, contracted by South Korean government, located the ship wreck deep in the South Atlantic Ocean, approximately 1800 nautical miles due west of Cape Town. A total of 22 crew members, comprising 14 Filipinos and 8 South Korean, are still unaccounted for and are considered to have gone down with the ship. Only two Filipino crewmen survived.

The accident brought the ever-long safety issue of liquefaction again on the surface. Although, there are no official conclusions attributing the sinking to liquefaction, some insurance officials tracked similarities with other incidents attributed to cargo liquefaction, such as the speed of the sinking. Iron ore, as also nickel ore, are some of the cargoes subject to liquefaction, as they contain high moisture. If the cargo liquefies, it can cause serious stability problems with a high possibility of capsizing.

4.4 Carriage of Sulphur Cargo

Sulfur is a solid that ignites readily and can be found in lumps, bars, and finely ground to extremely fine powder forms. Sulfur is yellow in color and explodes when it comes into contact with chlorates, nitrates, perchlorates, and permanganates. Water does not dissolve sulfur, and it can catch fire when it comes into contact with fat and oil. It is highly flammable, insoluble in water, corrosive to iron and steel, and requires a lime wash prior to loading. When sulfur comes into touch with a flame or spark, it will ignite easily. It is best to avoid using metal chains or slings when loading sulfur to prevent spark ignition.

Significant issues on a bulk carrier have brought attention to the difficulties that arise when transporting bulk sulfur loads. Small mistakes or oversights made when preparing a vessel to transport cargo can result in significant insurance claims. To prevent cargo claims and/or hull and machinery claims, among other things, the following guidelines and protocols need to be adhered to:

- all residues from previous cargoes must be removed.
- all loose paint, rust and/or scale must be removed.
- all traces of chlorides must be removed, especially those remaining after washing cargo holds with seawater.
- Cargo holds must be thoroughly fresh water washed and bilges drained.
- The cargo holds should be ‘grain clear’ prior to loading (i.e. equivalent cleanliness requirements as for grain cargoes).

- Holds must be inspected and approved and hatches must be watertight.

Main hazards

Any free water that is retained after loading sulfur filters to the bottom of the holds during the journey. The bilges are used to pump it out from there. A sulphurous mud is created when the residual water on the tank tops combines with the fine particles. Numerous studies have been conducted to better understand and prevent structural corrosion in vessels during the handling and transportation of sulfur. Acidic and electrochemical corrosion are the two processes that can result in a corrosion reaction.

Acidic corrosion is the result of an acidic reaction with elemental iron (steel). Sulfuric acid (H_2SO_4) is the acid in question. Significant corrosion does not occur until the solution's acidity reaches or falls below pH 2.

Electrochemical corrosion: The electrochemical reaction between iron and sulfur is known to be a redox (reduction/oxidation) reaction. The specific conditions that must be met for this reaction to occur are that the sulfur and iron must come into direct contact, and the sulfur must be moist. Experience has demonstrated that the majority of damage to a ship's hold structures during passage is caused by electrochemical corrosion rather than acidic corrosion.

Gas emissions

Hydrogen sulphide: Under some circumstances, bulk sulfur may release tiny amounts of hydrogen sulfide gas both during and after discharge. Because of this, there should be sufficient ventilation in any area where sulfur is used, stored, or where people are required.

Sulphur dioxide: Additionally, masters need to be aware that repairs involving heating or welding in areas that have previously been exposed to sulfur may produce sulfur dioxide. It is important to take the proper safety precautions.

Flammability

It is important for masters to be aware that when loading dry sulfur, static electricity can build up on the loading pipes and cause a fire. These fires can be put out with a fresh water spray or by dowsing with sulfur. Because ferrous sulfide is pyrophoric—it can catch fire when it comes into contact with air—it can ignite nearby tank tops when it is released. With careful application, a fine stream of fresh water may be able to put out such fires.

Pre-caution measures

The following prudent measures, to preclude risk of damage as a result of loading sulphur, should be adopted:

- Repair any damage to the paint coatings on the interior ship's side plating frames and internals, bulkheads, stools, and hopper tank plating up to the height where the cargo will be in close contact. You should also remove any loose rust and scale from the underside of the hatchcovers.
- Aluminium or epoxy resin based paints appear to be most effective.
- Although coating tank top plating is not mandated by the current Classification Societies regulations, it is acknowledged and important that paint coatings protect the plates while they are being transported with sulfur.
- Lime wash as per owner’s/shipper’s/charterer’s instructions and to the satisfaction of the pre-load surveyor.
- Cover the bilge strainer plates with hessian.
- The master should send a formal letter to the shippers and the stevedoring company prior to loading, requesting that the cargo be handled carefully to prevent grabs from loading more than 1.0 meters above the cargo level or tank top in order to prevent powder generation.
- Prior to loading the master should obtain a DCD (Dangerous Cargo Declaration) from the shippers or their agent
- Keep the bilge levels below the top level of the tank during the loaded voyage. Maintain a thorough record of the bilge pumping process, including approximations of the water volumes ejected from the holds.

- Remove all residues of sulphur from the holds upon completion of discharge and thoroughly wash down the holds with sea water and finally fresh water.
- If corrosion has developed, it needs to be eliminated by shot blasting or chipping before washing. The exposed steel was painted and coated.

Cargo holds preparation

Prior to loading sulphur, it is recommended that the receiving holds should be in a ‘grain clean’ condition, which requires:

- Removing all hard and loose scale, as well as other remnants of earlier cargo, from the holds. The upper sections of the holds should only be accessible with secure equipment. The best way to remove cargo remnants from otherwise unreachable places is with air wands.
- Thoroughly wash out the holds with sea water.
- Thoroughly wash out the holds with fresh water.

Lime wash application

It should be mentioned that while applying lime wash to cargo hold structures slows or lessens the corrosive reaction, it does not completely eliminate it. Therefore, it is ideal to apply the lime wash over any sound paint coatings that already exist. The lime wash then functions as a second physical barrier between the painted or bare steel surface and the wet sulfur, as well as an alkaline neutralizing barrier. The sulphur will eventually "consume" the lime wash due to its neutralising effect; at that point, if the paint coating isn't intact, the sulphur is back in direct contact with the ship's structure and the electrochemical corrosion process can start up again.

Based on experience with Canadian sulphur, a single coat of lime wash can effectively shield steel for approximately 30 to 40 days, and in certain situations, for an extended period of time. The suggested ratio for this mixture is roughly 60 kg of lime to 200 liters of fresh water. Before loading begins, the lime wash should also be given time to dry; otherwise, the protective "glaze" might not form correctly.

Corrosion incident from carrying sulphur

Upon survey of all cargo holds after a transport of sulphur cargo, serious corrosion was found {Officer of the watch, Corrosive cargo in the holds, 2013}. On the inclined plates of the hopper tanks and the lower stool of the transverse bulkhead, extensive damage in shape of groove corrosion was found with depth up to 9mm in places. This incident information refers to a 17,427 GRT Bulk Carrier in 1997. The cargo holds were originally painted, but surfaces had been spot-wise damaged by grabs during previous discharging operations. Further, the cargo holds had not been properly cleaned and the paint not properly maintained after previous sulphur cargoes. Thus, bare steel was exposed to attack by the corrosive cargo. In addition, the cargo holds had not been adequately ventilated.

4.5 Carriage of Bauxite

Over the past few years, there have been several reports of the loading and shipping of bauxite cargoes that may have liquefied or shown dynamic separation during the voyage. The issue is whether, in line with the most recent IMSBC code update for bauxite, the cargo was wrongly classified as Group A (solid bulk cargoes prone to liquefaction) instead of Group C (solid bulk cargoes not prone to instability) {The Swedish Club, Bauxite cargoes advise}.

Group A and Group B

Finding bauxite loads that are vulnerable to moisture-induced instabilities that may be significant enough to compromise vessel stability is the aim of the updates to the IMSBC Code. This is accomplished in accordance with the IMSBC framework by taking into account the range of particle sizes in the cargo as it was loaded and using that information to separate the low-risk

(Group C, not susceptible to moisture-induced instability) from the high-risk (Group A, susceptible to moisture-induced instability).

After studying international seaborne bauxite cargoes, the International Maritime Organization's (IMO) Global Bauxite Working Group came to the conclusion that, unless further testing indicates otherwise, bauxite cargoes falling within the following particle size range belong in Group A. Further bauxite loads should be categorized using Group C.

Bauxite fines (Group A):

a) More than 30% of the cargo (by dry weight) are particles with a diameter that is less than 1 mm, and

b) More than 40% of the cargo (by dry weight) are particles with a diameter that is less than 2.5 mm.

Admittedly, it is challenging for the Master to determine, based solely on visual inspection, whether the bauxite being presented for loading should be categorized as bauxite or as fines. Essentially, the Shipper's Cargo Information Sheet (CIS) is what the Master must rely on. The question of what reasonably easy independent checks the master could perform to ensure the shipper's information is reliable has long been open. There's no easy way to respond to this.

The can test

The can test is a basic hand test that is frequently performed by Masters to get a sense of the cargo's reaction to dynamic impact. It is advised in Section 8 of the IMSBC Code "for determining the possibility of flow." But because of a number of flaws in the test methodology, the results are merely suggestive and cannot be proven. The fact that a standard can cannot hold a representative sample of the cargo if the cargo contains particles larger than two centimeters in diameter is one example of the can test's limitations. This implies that the can test would only evaluate a small portion of the cargo, which might not accurately represent the behavior of the entire cargo with its entire range of particle sizes. This is not to argue that the Master shouldn't administer the can test. As allowed by the IMSBC Code, it should, but it's important to understand the test's limitations. For example, passing the test does not guarantee cargo safety, and failing the test does not indicate that cargo is unquestionably unsafe. If tests are carried out, we advise that they be documented with a trustworthy record of the test's location and time, either by video or still photography. It's important to note and take pictures of the sites where samples were collected for the tests. Images of sample locations should depict more than just the area where the sample was taken. Lower magnification images that illustrate the sampling location in relation to the entire pile or stockpile should be included. It is also helpful and encouraged to take pictures and videos of the cargo being offloaded from trucks, conveyor belts, and grabs in order to show the mechanical consistency and behavior of the cargo. Should the need arise, they can then be used for additional expert analysis.

Shipper's declaration

The Master should pay attention to the declared particle size in addition to the shipper's declaration of Group A or Group C when it comes to the cargo information sheet. Owners should confront shippers and charterers regarding this discrepancy in the CIS if the shipper has classified the cargo as Group C despite declaring particle sizes within the previously mentioned range. Furthermore, it is important to question the shipper if they have declared the cargo as Group C but have quoted a Transportable Moisture Limit (TML) or Flow Moisture Point (FMP). This is because these parameters only apply to Group A cargo, not Group C, and they could indicate that the IMSBC classification, on which the cargo declaration is based, was not understood correctly. This should contain the cargo particle size distribution curves, the test laboratory, the testing frequency, and the date of the relevant test results. Requesting the results of the cargo water content test and the methodology used for the cargo sampling is also beneficial. testing system (refer to the above Figure (i)). In any event, the data that forms the basis of the Cargo Declaration ought to be requested by the Master. This should contain the cargo particle size distribution curves, the test laboratory, the testing frequency, and the date of the relevant test results. Requesting the results of the cargo water content test and the methodology used for the cargo sampling is also beneficial.

The charterers would have violated the agreement if the shipper had misrepresented the cargo's particle size and/or the proper classification of the bauxite in the CIS. The general recommendation is to raise an alarm if the cargo appears to be in good condition but is still classified as Group C, or if the certificate is inconsistent as previously mentioned, as there is no easy way to determine whether the cargo is in Group A or Group C.

Legal considerations

The Master is allowed a fair amount of time to decide whether or not to follow the Charterers' instructions. Even if it is later found that the cargo is safe, the Master may have acted reasonably in postponing the loading and/or departure of the vessel (pending testing), depending on the circumstances. It would be prudent for the Master (as well as the Owners) to keep in mind, though, that each case will have its own unique set of facts and circumstances that will determine whether or not such a delay is reasonable.

Members should consider drafting bespoke clauses in the charterparty concentrating on the following issues:

1. More precise conditions regarding when the ship would be deemed off-hire (or not) in relation to the amount of time the master needs to decide whether the cargo belongs in Group A or Group C.

2. There are rider clauses and stowage clauses (such as Clause 8 of the NYPE 1946 form) that require the Charterers to certify to the Master that the cargo has been packed, labeled, loaded, stowed, carried, and discharged in compliance with the CIS, the IMSBC Code, and the IMO IMDG Code. Nonetheless, it is helpful to confirm that these clauses are expressed precisely.

3. Expressed indemnity clauses can always reinforce the implied right of Owners to an indemnity from Charterers regarding the safety of the cargo being loaded, even though common law cases support this.

Accident from carrying bauxite cargo

On 2 January 2015, the Bahamas-flagged Bulk Carrier, with 19 crew members onboard, was carrying 46,400 tonnes of bauxite from Malaysia to Hong Kong. While off Vietnam on New Year's Eve, the vessel received an email from their weather routing provider highlighting adverse weather conditions expected in the region. In the next day, the vessel started rolling more heavily as the weather started to deteriorate. At approximately 0640, the general alarm was sounded followed by an announcement by the Master directing all crew to proceed to the bridge. While in his cabin, the chief cook felt the vessel suddenly starting to roll more heavily, particularly to starboard. He left his cabin in order to make his way to the port side lifeboat, at this point the vessel suffered a black out, emergency lights then came on, and the vessel stopped rolling and adopted approximately a 45o list to starboard. Due to the angle of list, the Chief Cook was unable to make his way to the port side access door and decided to utilize the internal staircase and proceed up to ‘C’ deck, where he met the Master. He instructed the Chief Cook to follow him and together they exited the accommodation block via the starboard side access door. No other crew were seen onboard after that time. Having exited the accommodation area of the vessel, both men found themselves on a small platform on the starboard side, aft external stairway with the waves washing over them. The Master, wearing his lifejacket, jumped into the sea followed shortly after by the Chief Cook who at this point had donned his lifejacket – neither were wearing an immersion suit. The two men stayed together while swimming away from the vessel prior to it sinking. As they looked back from a safe distance, despite the heavy seas, they could just see that the vessel had almost disappeared beneath the waves. At 1410, a good Samaritan container ship reported sighting the two persons and believed them both to be alive. The tugboat headed to assist and by 1556 the two crew were recovered onboard, but only the Chief Cook was alive. Two more crew members were recovered deceased. A total of 9 vessels and 3 aircraft were assisting with the SAR operation to find the remaining crew. Search and rescue efforts continued for a further 2-3 days, but no further crew were located.

Findings:

Three factors failed to raise adequate awareness or warning signs:

1) the uncharacteristic speed reduction en route 2) the results of the requested ‘Can Test’ 3) the incomplete noon reports that should have informed the Company on the condition of the cargo in the holds.

Additionally, there was significant evidence to identify that the 46,400t of bauxite loaded over the course of the 13-day period had an average moisture content of 21.3%. It was noted that a total of 186.55 hours of loading was lost due to rainfall – the equivalent of 7 days of loading over the period. The infrastructure available to adequately store and transport bauxite in Kuantan increased the exposure of the bauxite to the elements. An independent inspection was not requested by the Master to verify the properties of the cargo prior to loading onboard. The absence of an independent inspection resulted in the cargo being loaded without its physical properties and moisture content being verified against the parameters of the IMSBC Code schedule or the cargo declaration form.

4.6 Carriage of wood pellets

Cargo description

Because wood pellets are a non-fossil fuel for heating, there has been a rise in their production and transportation in recent years. It is acknowledged that Scandinavia and North America are the two primary manufacturing nations.

The manufacturing technique described below is based on one that is utilized in Canada, however it is thought that comparable processes are employed elsewhere. The pellets are made entirely of sawdust and wood shavings; no binders or additives are used in their production. After being dried, the sawdust and shavings are ground into particles as small as two millimeters. After that, the particles are roughly 3.5 times compressed to create pellets, which are normally between 10 and 20 mm long and 3 and 12 mm in diameter.The temperature rises as a result of the compression. Depending on the kind of wood used, the pellets can range in color from blond to brown and have a moisture content of 4 to 8%.

The material loaded onto a ship for transportation is made up of pellets, fragments of broken pellets, and wood dust because of movements during transport and physical handling.

Naturally, the wood pellets are combustible and can be lit using a variety of sources. Additionally, under the right containment conditions, the pellet-related dust, when scattered and ignited, can cause a dust explosion. It is possible for bulk piles of wood pellets that have been stored for a long time to spontaneously ignite due to the process of self-heating in areas with high moisture contents.Wood pellets not only pose a risk during combustion, but they also oxidize to release carbon dioxide and carbon monoxide. This can cause a hazardous drop in the oxygen content of a closed space, like the hold of an unventilated ship, as well as the development of a dangerous concentration of toxic (and flammable) carbon monoxide.

In a recent instance, about 18 days after the cargo was loaded, a sealed cargo hold of a ship carrying wood pellets had a carbon monoxide concentration of about 1%. At this point, the oxygen content was less than 1%. The literature has reported carbon monoxide emission rates from wood pellets ranging from 100 to 885 mg/ton/day.

Although the production of carbon monoxide from burning wood products in reduced oxygen environments is well known, the gas's unexpected low temperature emission is not. The autoxidation of fats and fatty acids in the wood has been proposed as the source of the gas, although the exact causes of this process remain unknown. There have also been reports of stored wheat and rapeseed producing carbon monoxide.

Consequently, a submission regarding the transportation of wood pellets was made to the IMO Sub-Committee on Dangerous Goods, Solid Cargoes, and Containers on July 1, 2004. The suggestion in the submission was to add a new section to the BC Code regarding wood pellets, mentioning the risk of carbon monoxide production.

The 2005 Edition of the BC Code 2004 includes an entry for wood pellets as a result of this submission being approved. Stevedores are now aware of the risk of carbon monoxide production and oxygen depletion, and they regularly hire gas specialists to inspect areas that contain or have previously contained wood pellets. Obviously, the ship's crews and anyone else who might need to enter a cargo hold that contains or has recently contained wood pellets need to be aware of this as well.

Temperature effects on gas releasing

Over time, all biomass breaks down gradually, releasing harmful and oxygen-depleting gases like methane (CH_4), carbon dioxide (CO_2), and carbon monoxide (CO). During storage, wood pellets release a variety of compounds, including multi-carbon aldehydes like hexanal and pentanal and one-carbon compounds like CO, methanol, formic acid, and formaldehyde. The most likely reason is the oxidation of fatty acids and other substances in the wood. Although the oxidation processes take place below room temperature, high temperatures speed them up.

While CO_2 is most likely produced by the thermal oxidation of products of aerobic degradation, CH_4 generation in a traditional biomass composting system is typically linked to the anaerobic breakdown of biomass. A high CO/CO_2 ratio is favored by a high temperature. Both CH_4 and CO_2 emissions rise with temperature; at higher temperatures, CH_4 generation is preferred over CO_2 generation.

4.7 Carriage of steel cargoes

Steel cargoes are divided in 2 categories {Skuld P&I, Carriage of steel cargoes}:

- Packed or wrapped (e.g. wire rods, coated steel in coils and packages, cold rolled steel sheeting in coils and packages)
- Not packed or wrapped (e.g. steel slabs, scrap, steel plates)

At loading port

It's critical to avoid starting loading before a stowage plan has been decided upon. Perhaps stevedores are eager to get going. Even though it might mean waiting, the Master can prevent worse delays later on and save the lives of those on board as well as damage to the cargo and his ship by approving the stowage plan before the beginning of loading. If a surveyor is present, he ought to help the master verify the stowage plan and offer advice. It is important to exercise caution when loading incompatible cargoes in the same compartment as steel cargo, including fertilizers, chemicals, sulphur-containing materials, and frequently, hygroscopic cargoes.

In case of rain, it is remarkable to note that vapour pressure and air humidity rise in a ship's holds when there is wet cargo present. Therefore, moisture damage to cargo that was sound and dry upon shipment will result from the presence of wet cargo in the holds.

Products that are packed or wrapped in Category A cannot be loaded into the quay or left uncovered in the event of rain.

Products in Category B that are not packed or wrapped are frequently kept on the open quay and loaded in the event of light rain. As long as they are not being placed in the same hold as dry goods, this is typically acceptable. For any wet cargo, a suitable description (such as "Wet before Shipment") should be ready to be added to the bills of lading and the mate's receipts. Be cautious of coils that seem dry on the outside but leak water when the windings are lifted. In order to prevent rain from harming cargo in the holds, hatch covers and all other deck openings should be closed well in advance.

In order for the Master to verify that the timings on the Statement of Facts that are being presented to him for signature correspond with the timings in the ship's log, a careful record of the timing of any rain and the opening and closing of hatch covers should be kept. He is also responsible for loading, stowing, carrying, tending to, and unloading the cargo properly and carefully; surveyors are available to assist and advise the Master. He might eventually have to provide evidence that he carried out this duty and, in doing so, did everything within his power to safeguard the cargo while it was in his care.

Vessel's requirements

Steel is a deadweight cargo with a high density. Tank top overload is a risk that needs to be recognized and avoided. The allowable tonnage should be determined by the master, and this amount should never be exceeded. The permissible tonnage is calculated as follows: Area of tank top (M2) x Tonnes per M2 tank top strength limitation.

The Classification Society has authorized the tank top strength limitation figure, which is provided by the shipbuilder. Typically, the figure doesn't change over a ship's lifetime. Over time, a ship's component parts lose strength and become less robust. When determining the allowable tonnage, older ships should be treated with more caution—a larger safety margin should be allowed. The tank top plating may become deformed if the allowable tonnage is exceeded. Dunnage needs to be properly distributed to prevent spot overloading and to distribute pressure evenly over the tank top, reducing structural deformation in the process.

Prior to starting the loading process, the surveyor should inspect the cargo holds. Before any cargo is loaded, the surveyor should report right away if the hold is not in a suitable condition. Cargo compartments that have been cleaned in salt water before loading need to be washed one last time in fresh water to get rid of any salt crystals. The surveyor needs to use silver nitrate to do spot checks on the plating on the tank top and the sides of the holds. This is especially crucial if the discharge port is in the US, as discharge tests of this kind are frequently performed there.

Watertightness

High density deadweight cargoes are virtually invariably composed of steel. These cargo ships operate extensively in a seaway and have a high range of stability, which places concentrated stresses on the hull structure in a number of places, particularly around the hatchways. All of the steel hatch closing appliances' component parts must be kept in excellent condition if the hatches are to stay waterproof. This holds true for all other primary deck openings as well.

Should instructions be given, the surveyor should test the hatch cover panels for watertightness in addition to visually inspecting the cargo holds and hatch covers. Before the journey begins, the surveyor should make note of any flaws, report them to the responsible deck officer, and have them expertly fixed.

Three methods of testing are available: ultrasonic; hose; chalk.

Ultrasonic test:

This can be the most reliable method. It is the preferred method of testing, but only if the surveyor is certified to carry out ultrasonic testing and is using properly certified and calibrated equipment

Hose test:

The test must be conducted in accordance with the 1985 International Guidelines of IACS (The International Association of Classification Societies Ltd.). They stipulate that the hose's nozzle end should be held at a maximum distance of 1.5 meters from the joint being tested, that the nozzle diameter must be at least 12 mm, and that the pressure to be used must be adequate to allow for a free height of water with the stream directed upwards of at least 10 meters. The hatch panels meet to form a narrow gap, and the actual joint that needs to be tested is located somewhat below the surface of the panels. As a result, when testing, the hose's water cannot be directed onto the joint itself, creating a watertight seal. Actually, the force of the water flowing toward the joint is lessened by the hatch panels' surface. Since there was no other known method available except the less-than-satisfactory chalk test, hose testing has been the primary method of testing for many years. However, hose testing is still an acceptable method of testing for watertight integrity. It is usually necessary to use two surveyors and in order to increase the efficiency of the test it is advisable to plug the drain holes on either side of the transverse joint so that the guttering can be filled with water.

Chalk test:

The last option should be to use this test method. In the event that alternative techniques are not feasible, this test is carried out by covering every compression bar with regular chalk, shutting the hatches, and then opening them again to check for chalk imprints on the sealing rubbers. One advantage of this test is that it can be carried out in the ship with or without cargo. The application of the chalk to the compression bar, however, takes time. The presence of both light and heavy imprints on the rubber gaskets may cause confusion regarding the true effectiveness of the test. Naturally, areas where there is no imprint must mean absence of contact between the compression bar and the rubber seal; these are obviously areas of potential leakage. This test is more often used, and is useful, when rubber gaskets have been renewed.

4.8 Transportation of cement and clinker cargo

About 5% of dry bulk trade consists of cement cargoes, which can be very problematic to transport in conventional bulk carriers as opposed to specialized cement carriers. Direct loading of clinkers from the processing plant may result in very high temperatures, which could seriously harm the hold paint coating and, more significantly, cause the fuel temperature in double bottom tanks to rise above the flash point. It is important to confirm the cargo temperature before loading and to keep an eye on it during. Cargo over 80°C should be allowed to cool before loading, and no cargo over the fuel's flash point in the double bottoms should be accepted. Not to be handled when it's raining. IMSBC Group C cargo is cement. Heat-resistant coatings based on alkyd are intended to endure elevated temperatures and typically mitigate coating damage. When it leaves the production site, its temperature might be as high as 110ºC, and it can occasionally be loaded at as low as 80ºC. There have been reports of temperatures reaching up to 100ºC, which may cause issues with the hold coatings and possibly pose a risk to the fuel oil double-bottom tanks.

After carriage, it could need a thorough cleaning. Only portable pumps should be used to clear wash water while the area is being held clean. Conventional ships typically have the issue of cement dust and cargo residue collecting in the hard-to-reach and dirty areas above the tank top.

Bilge wells should be sealed to keep cargo from entering. Equipment, machinery, and lodging that will be shielded from cargo dust. It is required that workers exposed to dust put on masks, goggles, and other suitable safety gear.

The primary component used in the creation of cement is clinker. Clinker loading and hold cleaning are comparable to cement loading; however, since clinker lacks a binding agent, it does not harden as much as cement. To make regular cement, cement clinker—a semi-manufactured material—must be ground into a fine powder. It might pose less of an issue than the cement carriage. Its primary benefit is that it doesn't solidify when exposed to water, which lessens the potential harm it could do to the ship. It still needs to be kept dry, though, to avoid caking. Its chloride content rises as a result of seawater contamination, which has a negative impact on the cement made from it.

Cement is frequently discharged into warmer climates with higher air humidity after being exported from areas with colder seas. The volume of cement powder can shrink by up to 10% after it has settled after being loaded. Under these circumstances, water vapor has the potential to condense and solidify the cement, especially on the exterior, beneath the main deck sections as well as in other cargo hold sections. When loading cement, a ship is frequently fully ballasted when it comes alongside, and as loading goes on, the top side ballast tanks are dropped. This may cause the plating on the top hopper side to perspire, which makes it easier for the cement dust to stick and become harder to remove.

Holds' preparation before loading

The holds (sides and tank top) and bilges must be completely dry, clean and odour-free. Sugar and fertilizer residues from earlier loads could be problematic and lead to a failed hold inspection. Make sure the hold is totally free of any leftover sugar cargo residue because even a small amount of sugar can cause a cement cargo to deteriorate rapidly.

Before loading:

- the hold air should be dry; if you plan to be on board for several days before loading, use dehumidifiers to prevent condensation during the journey.
- Tanks next to loaded holds should, if at all possible, not have cold water ballast.
- Every scupper hole, bulkhead, and tank top indentation should have clean, dry holes. Think about using masking tape and plastic sheets to cover manholes and recesses.
- Before loading, the bilge, bilge wells, and tank tops need to be properly cleaned and dried. Problems can arise from cement getting into wet bilges and bilge wells. Hardened cement clogs in bilge lines can be very problematic.
- bilge well strainers and bilge well lids must have clear drain holes, and be clean and free of debris
- The drain and bilge system's non-return valves need to be examined and verified to be in working order. There have been claims that the bilge line system has allowed water to enter the holds due to non-return valves. When this happens with a cargo of cement, the outcome can be very costly and time-consuming. In these situations, it might be essential to replace the bilge lines.
- the bilge wells must be protected using good-quality burlap that is firmly in place so as to allow water to be drained in an emergency

Cement dust is created during the loading process into holds and settles on all exposed areas. After loading is finished, every area needs to be swept and/or cleaned to avoid any loose cement from solidifying if it comes into contact with rain or seawater while the ship is traveling. All accommodation, mast houses/store rooms and vents should be shut, wire drums and electrical boxes on deck should be covered and closed off. Pilot ladders should be covered, air conditioning should be on recirculation and deck scuppers should be blocked.

During loading and before departure

The atmosphere in the cargo holds should be kept as dry as possible. Cement holes should be closed when the holds are not being loaded or discharged, particularly if there is a possibility of rain. The use of compressed air for cleaning the main deck, hatch covers, and exposed piping may be prohibited in some ports due to anti-pollution regulations. Hatch coaming trackways, drainage channels and drain holes should be cleaned and free of cement if possible weather permitting. Blocked drain holes and channel bars will become clogged with hard cement in heavy weather or rain

Following important instructions shall be duly followed after discharging cement

- The bulkheads and tank top should be cleared of most cargo residues by using brushes to dry clean cement dust.
- crew or stevedores should follow up in the cargo holds when the discharge is almost completed. Cargo residues should be collected and filled into the grabs for landing. Shovel clean means that the stevedores discharge only what they are able to get into the grabs without sweeping.
- Bilge wells ought to be dust-free and dry.
- Bulkheads in the cargo hold, the undersides of the hatch covers, and the hatch comings should be cleaned with compressed air and swept.
- Using high-pressure hoses, clear away all solid residues, sweep the area thoroughly, and flush with seawater. The holds need to be cleaned using high-pressure air or water after being dry cleaned. When required, high-pressure cleaning pumps and chemicals can be used.

If hard residues are not removed by conventional high-pressure hoses using seawater, it may be necessary to call in a professional cleaning company, which can use acids to remove the persistent hardened cement. Hard cement residues, if not removed during the high-pressure wash, can be removed by high-pressure cleaning machines or acid cleaners.

After cleaning, all areas should be flushed with freshwater and in order to avoid blocking the bilge system, portable diaphragm pumps may be used to remove the washings. Prior washing the holds, the bilges and tank tops should be thoroughly cleaned. Before drying the tank top, the bilges should be flushed for at least thirty minutes to make sure cement hasn't clogged them. Hardened cement clogs in bilge lines can be very problematic.

5. Bulk Carriers Fleet Evolution

The maritime industry's largest segment, dry bulk, has an effect on nearly every facet of the economy. The fleet of bulk carriers has changed significantly in the last ten years. Technology developments in shipbuilding, changes in trade trends, and changes in environmental regulations occurred between 2013 and 2023. The fleet's deadweight tonnage (DWT) capacity has increased significantly over the last ten years due to changing trade patterns, rising raw material demand, and technological advancements. This article examines the fleet's expansion during the previous ten years and offers projections through 2025 {AXSMarine: Bulk Carriers Fleet Growth, 2024}.

The DWT capacity of the world's fleet of bulk carriers increased significantly between 2013 and 2023. The expansion of large economies like China and India, which greatly increased the demand for bulk commodities, was one of the main drivers of this growth. The primary trends during this time period are highlighted by the points below:

Economic Growth and Demand for Commodities: Growing economies, especially China and India, have been rapidly industrializing, which has increased demand for dry bulk commodities. Larger and more frequent bulk carriers became necessary as a result. The countries involved in the Belt and Road Initiative and other infrastructure projects needed a lot of raw materials, which increased demand for vessels.

Technological Advancements: Improvements in shipbuilding technologies led to the construction of more efficient and larger vessels, contributing to the overall increase in DWT capacity. The evolution of Very Large Ore Carriers (VLOCs) and Newcastlemax dry bulkers, with DWT capacities exceeding 200,000 metric tonnes, made these types more common. The constant growth of the so-called Ultramax bulk carriers fleet over the last ten years illustrates this trend very well. On average, these vessels are only 10 meters longer than the Supramax but have upwards of 12% more cargo capacity. Naturally, this translates to more cargo per voyage, greater operational efficiency, and reduced cost per freight unit.

The shift towards eco-friendly designs also played a role, with many new ships being built to meet stringent environmental regulations. Many older vessels were retired and replaced with newer, more fuel-efficient ones. This modernization was driven by a combination of regulatory pressures and the need to reduce operating costs.

Replacement of old vessels with new-buildings does not necessarily mean the introduction of technological advancements, which make the cargo transportation safer. However, key-parts of the vessel such as cargo holds, bilges, bilge covers, hatch covers, rubber packings, ventilators etc., are undoubtedly more safe and trustworthy in a new-building ship, than in 15 years old which their condition depends on the quality of maintenance that she has received over her lifetime. As a result, the trend of retirement of old vessels and the replacement with new ones might be taking place due to other factors, mostly energy related, but also assists to the safe transportation of the cargoes.

6. Conclusion

From the above research and analysis arises that the factors affecting and defining the safe carriage in bulk carrier industry can be numerous. Engagement of multiple parties during the transportation process can further complicate it and thus it is believed that the value of this analysis might be found helpful, since it delves into the critical aspects of ensuring safe transportation, focusing on bulk cargo characteristics, crew member instructions, and expert insights.

Regardless the cargo, there are specific steps that need to be followed at any stage of the carriage process and could be summed up as following:

1) Holds must be in all respects ready and clean up to standards that depend on the nominated cargo. Hatch covers' watertightness shall be checked via specialized tests that have be thoroughly described in previous chapters.

2) Cargo declaration should be received prior loading and carefully read from Master and office personnel to ensure shipper's compliance with IMSBC code's requirements in respect to cargo properties and related hazards. Depending cargo properties, relevant precaution measures shall be taken from crew for as long as the cargo stays on board
3) Loading should continuously be monitored from the crew, which is also responsible for checking the apparent condition of the cargo and take temperature measurements until the completion of the operation
4) Cargo should be prudently monitored and treated according to the shipper’s declaration and IMSBC code recommendations until discharging

Of course, all the above steps are indicative and must be adjusted and adopted for every different cargo to be carried. The validity of provided data was confirmed when compared to the ex-Master's insight, which lent weight to the thesis's arguments and provided a sense of authority.

The safety of bulk cargo transportation is underpinned by a robust regulatory framework and a comprehensive set of safety measures. International Maritime Organization (IMO) conventions like SOLAS and MARPOL provide the foundation for global standards, ensuring consistency in vessel construction, equipment, and operations. These conventions address various hazards, including fire, explosion, liquefaction etc.

Beyond regulations, safety practices are essential for ensuring safe operations. Pre-loading inspections verify the vessel's condition and stability, while cargo stowage plans ensure proper distribution and prevent stability issues. Furthermore, crew training and familiarization to company’s SMS is vital for equipping seafarers with the knowledge and skills to handle cargo safely and respond to emergencies. Equipment maintenance is also very crucial to prevent breakdowns and accidents, ensuring the reliability of cargo handling equipment.

Shore-based offices play a vital role in coordinating various aspects of the voyage, from port clearance and cargo inspections to emergency response. Effective communication between the ship and shore-based office is essential for addressing issues promptly and ensuring smooth operations.

By adhering to regulatory frameworks and implementing comprehensive safety measures, the bulk cargo industry can significantly reduce the risk of accidents, environmental damage, and loss of life. This effort between regulatory bodies, shore-based personnel, shipowners and seafarers is essential for ensuring the safe and efficient transportation of bulk cargoes.

Appendix - Interviewing an ex-Bulk Carrier Master

1) Interviewer: Let's get started! So, you've had a long career in bulk cargo shipping, correct?

Bulk Carrier Master: Absolutely. I've spent many years at sea, most of it on various bulk carriers. I've seen the industry evolve significantly over the years, and I've witnessed both the challenges and advancements in safety.

2) Interviewer: What do you consider to be the biggest safety concerns in bulk cargo carriage today?

Bulk Carrier Master: Well, there are several, but I would say the most pressing issues revolve around cargo handling, stability, and environmental risks. Improper loading and unloading procedures can lead to accidents and injuries. Ensuring the vessel's stability is crucial, especially when carrying dense or uneven cargoes. And of course, the environmental impact of bulk cargo operations cannot be ignored, with issues like oil spills being major concerns.

3) Interviewer: How have safety regulations and practices changed over the years?

Bulk Carrier Master: There have been significant improvements. International Maritime Organization (IMO) regulations have become more stringent, and there's a greater emphasis on risk assessment and prevention. Technological advancements like advanced navigation systems and structural monitoring have also played a role in enhancing safety. However, there's always room for improvement, and the industry must continue to adapt to new challenges.

4) Interviewer: What are some of the latest technologies or practices being implemented to improve safety in bulk cargo carriage?

Bulk Carrier Master: There's a growing focus on digitalization. Technologies like remote monitoring, predictive maintenance, and data analytics can help identify potential risks and optimize operations. Additionally, there's been a push for more sustainable practices, such as reducing emissions and minimizing environmental impact.

5) Interviewer: Let's delve deeper into specific areas. Starting with regulatory measures, how have recent IMO regulations impacted safety in bulk cargo carriage?

Bulk Carrier Master: The IMO has played a pivotal role in enhancing safety standards. Regulations like the International Convention for the Safety of Life at Sea (SOLAS) and the International Convention for the Prevention of Pollution from Ships (MARPOL) have established comprehensive frameworks for vessel construction, equipment, and operations. These regulations have helped to standardize practices and improve safety across the industry.

6) Interviewer: What operational practices have proven effective in reducing accidents and incidents in bulk cargo carriage?

Bulk Carrier Master: Proper cargo handling procedures are essential. Ensuring that cargoes are loaded and unloaded correctly, and that the vessel's stability is maintained throughout the voyage, are critical. Regular inspections and maintenance of equipment, as well as effective crew training, are also crucial. In addition, conducting regular inspections and maintenance of equipment, such as winches, cranes, and cargo holds, can help to identify and address potential problems before they lead to accidents.

Providing crew members with adequate training on safety procedures, emergency response, and the risks associated with cargo handling is essential for preventing accidents. A safe and effective operation depends on the crew of the ship, shore personnel having effective communication and coordination. Also, having emergency response plans in place and ensuring that crew members are trained on how to respond to emergencies can help to minimize the impact of accidents and incidents.

Finally, accidents and incidents can be avoided by regularly conducting risk assessments to identify potential hazards and implementing the necessary mitigation strategies. For instance, such RAs can be conducted prior operating hatch covers, working inside of cargo holds for cleaning, performing hose test, entering hatch while discharging operation still in progress etc.

7) Interviewer: Environmental safety is a major concern in bulk cargo carriage. What measures can be taken to reduce the risk of pollution and environmental damage?

Bulk Carrier Master: Implementing effective oil spill prevention and response measures is essential. This includes having adequate oil spill response equipment on board and being prepared to contain and clean up spills if they occur. Additionally, preventing cargo contamination and ensuring that ballast water is treated properly can help protect the marine environment. Ballast water management is another area of concern, as untreated ballast water can introduce invasive species into new environments. The implementation of the Ballast Water Management Convention requires vessels to manage their ballast water effectively, either through treatment systems or by conducting exchanges in open seas where possible. Compliance with these regulations not only protects local ecosystems but also minimizes the risk of costly fines and penalties.

8) Interviewer: You mentioned the importance of proper cargo handling procedures. Can you provide some specific examples of best practices in this area?

Bulk Carrier Master: Certainly. One crucial aspect is ensuring that the cargo is loaded and stowed properly to prevent shifting or damage during the voyage. This involves making accurate calculations in respect of cargo distribution, ballast and bunker consumption prior loading , as well as verifying the stability of the vessel before and after loading. Additionally, it's essential to follow the shipper's instructions for handling specific types of cargo, especially those with hazardous properties. When loading bulk cargoes like grains or coal, it's important to ensure that the cargo is distributed evenly throughout the holds to maintain the vessel's stability. Another important aspect of proper cargo handling is preventing cargo contamination. This is especially important for food-grade cargoes or those that are sensitive to moisture or other contaminants. Measures like using clean containers and equipment, avoiding cross-contamination, and following proper hygiene practices can help to ensure the quality and safety of the cargo.

Additionally, it's significant to have a clear understanding of the properties of the cargo being handled. Some cargoes may have special handling requirements, such as being sensitive to temperature or humidity. Failure to comply with these requirements can lead to damage of the cargo.

9) Interviewer: How can companies create a culture of safety among their seafarers?

Bulk Carrier Master: A strong safety culture starts from the top. It's essential for ship owners and managers to demonstrate their commitment to safety and to provide the necessary resources and support to ensure a safe working environment. This includes conducting regular safety training, encouraging open communication about safety concerns, and recognizing and rewarding safe behavior. Additionally, it's important to investigate accidents and incidents thoroughly to identify root causes and implement corrective measures.

10) Interviewer: How is crew safety ensured during cargo handling operations?

Bulk Carrier Master: Crew safety is a top priority during cargo handling operations. Several measures are implemented to protect them:

- **Personal Protective Equipment (PPE):** Crew members are provided with appropriate PPE, such as safety helmets, gloves, and reflective vests, to protect them from potential hazards. While working in colder places, extra equipment is provided to ensure crew's safety.
- **Safe Working Practices:** Clear procedures and guidelines are established to ensure that cargo handling operations are carried out safely. This includes proper use of equipment, maintaining a safe distance from moving machinery, and following established safety protocols.
- **Crew Training:** Regular training programs are conducted to educate crew members about safety procedures, emergency response, and the risks associated with cargo handling.
- **Risk Assessments:** Risk assessments are conducted before and during cargo handling operations to identify potential hazards and take appropriate precautions.
- **Supervision:** Supervisors are responsible for monitoring cargo handling operations and ensuring that safety measures are being followed.
- **Communication:** Clear and effective communication between crew members is essential for ensuring a safe working environment.

11) Interviewer: How does the shore office play a crucial role in ensuring smooth cargo transportation and operations?

Bulk Carrier Master: The shore office is essential for coordinating and managing various aspects of the voyage. They handle tasks like booking berths, arranging cargo inspections, and coordinating with charterers and agents. Additionally, they monitor the vessel's progress, provide technical support, and handle emergency situations. Effective communication between the shore office and the ship is vital for ensuring a smooth and efficient operation.

Interview Consent Form

Title of Project: DISSERTATION – BULK CARGO SAFE CARRIAGE AND MONITORING

Principal Investigator: MICHAIL LAZAROU, DEPARTMENT OF MARITIME STUDIES

Faculty Supervisor: EVANGELOS TSIOUMAS, ASSISTANT PROFESSOR, DEPARTMENT OF MARITIME STUDIES

You are invited to participate in a research study conducted by Lazarou Michail from the Maritime Studies department at University of Piraeus This project is supervised by Evangelos Tsioumas, who is Assistant Professor in Department of Maritime Studies.

Purpose of the Research

This research aims to gain insights into Maritime Industry. Your participation will involve sharing your views and experiences in an interview setting.

Interview Procedures

The interview will take place at Piraeus and will last approximately 1-2 hours. There are no anticipated risks or discomforts associated with participating in the interview.

Confidentiality

Your identity will remain confidential, and your name will not be associated with the interview data. The consent form will be securely stored and accessible only to the researcher. The data will be stored for 5 years and will be either destroyed or retained for future research. Findings will be reported in aggregate form, ensuring anonymity.

Contact Information

If you have any questions regarding this research, you may contact:

- **Student Investigator:** Michail Lazarou, mikelaz1997@hotmail.com
- **Faculty Supervisor:** Evangelos Tsioumas, vtsioumas@unipi.gr

Voluntary Participation

Participation in this research is voluntary. You may decline or withdraw at any time without any penalty.

Acknowledgment and Signature

By signing below, you confirm that you have read and understood the contents of this consent form and agree to participate in the interview.

____

Typed/Printed Name of Participant

____ ______________

Signature of Participant Date

____

Typed/Printed Name of Investigator

____ ______________

Signature of Investigator Date

References

AXSMarine (2024, July). *Bulk Carriers Fleet Growth: A Decade in Review and 2025 Outlook* *https://public.axsmarine.com/blog/bulk-carriers-fleet-growth-a-decade-in-review-and-2025-outlook*

Britannia P&I Club (2021, February). *Guidance on the carriage of coal cargo.*

https://britanniapandi.com/2021/02/carriage-of-coal/

Britannia P&I Club (2023, September). *Heat damage to agricultural cargoes on board and how to avoid it.*

https://britanniapandi.com/2023/09/heat-damage-to-agricultural-cargoes-on-board/

Bulk Carrier Guide. *Bulk cement & clinker carried in conventional bulk carriers*

https://bulkcarrierguide.com/bulk-cement-&-clinker-handling.html

GOV.UK (2015, March). *Smouldering coal cargo fire in several holds on bulk carrier Belo Horizonte*

https://www.gov.uk/maib-reports/smouldering-coal-cargo-fire-in-several-holds-discovered-when-bulk-carrier-belo-horizonte-arrived-at-its-discharge-port

International Maritime Organization. *Bulk Carrier Safety*

https://www.imo.org/en/OurWork/Safety/Pages/BulkCarriers.aspx

International Maritime Organization. *International Maritime Solid Bulk Cargoes (IMSBC) Code*

https://www.imo.org/

Marine insight (2021, April). *9 Common Hazards Of Bulk Cargo On Ships*

https://www.marineinsight.com/marine-safety/9-common-hazards-of-dry-bulk-cargo-on-ships/

Marine insight (2024, July). *Real Life Incident: Enclosed Space On Ship Claims One Victim, Spares Two*

https://www.marineinsight.com/case-studies/real-life-incident-enclosed-space-on-ship-claims-one-victim-spares-two/

North of England P&I (2017, March). *Iron ore fines – Loss prevention briefing for North members*

https://www.nepia.com/

Officer of the watch (2013, May). *Corrosive cargo in the holds*

https://officerofthewatch.com/2013/05/10/corrosive-cargo-in-holds/

Safety4sea (2019, September). *Bulk Jupiter sinking: A stark reminder of bauxite cargo risks*

https://safety4sea.com/cm-bulk-jupiter-sinking-a-stark-reminder-of-bauxite-cargo-risks/

Safety4sea (2019, April). *Learn from the past: Stellar Daisy sinking*

https://safety4sea.com/cm-stellar-daisy-sinking-two-years-on-and-what/

Skuld P&I. *Carriage of Steel Cargoes*

https://www.skuld.com/topics/cargo/steel/carriage-of-steel-cargoes/

Skuld P&I. *Transportation of cement – A loss prevention article*

https://www.skuld.com/

The Swedish Club. *Cargo advise – Bauxite cargoes*

https://www.swedishclub.com/

The Swedish Club. *Cargo advise – Grain and oilseed cargo*

https://www.swedishclub.com/