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FIRE DRILLS AND PROTECTION ONBOARD A SHIP

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ABSTRACT

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The maritime industry plays a pivotal role in global trade and transportation, with ships serving as crucial vessels for the movements of goods and people across the world's oceans. Ensuring the safety of maritime operations is paramount, and one of the most significant threats to this safety is the occurrence of fires onboard ships.

The purpose of this thesis is to discuss and explore the importance of fire drills onboard a ship. Taking into consideration the safety of both the crew members, the vessel and cargo. The primary objective of this thesis is to find out to what extent do safety drills contribute to the crew members’ preparedness for real emergencies. This thesis also focuses on aspects such as training, because it plays a vital role in safety drills.

In this thesis qualitative research method was used, this was done by asking questions directly to the crew, while the author writes down the answers from the participants, it is more of a discussion session.

These theses follow the case study research design process, because this process will allow one to conduct a more detailed study of the topic in question and it will help one to be able to focus on gaining a holistic understanding of the case. This method also helps one to use knowledge from previous research papers and make congruent conclusions.
Results show that fire drill and Fire prevention systems are designed to eliminate possible fire threats, while fire protection minimizes damage and aids in the safe evacuation of the scene.

Keywords: Safety, Training, Fire drill, Quality, Emergency.

FOREWARD

The completion of this thesis on "Fire Drills and Protection Onboard Ship" has been a journey marked by collaboration, support, and shared dedication to the pursuit of maritime safety. As I stand at the threshold of this academic achievement, I am deeply grateful for the invaluable contributions of the individuals and institutions who have been instrumental in the realization of this endeavor.

First and foremost, I express my sincere gratitude to my thesis advisor, Markus Vitikkala, whose guidance, expertise, and unwavering commitment to academic excellence have been the cornerstone of this research. Your mentorship has not only shaped the trajectory of this thesis but has also fostered my growth as a researcher and a maritime professional.

I extend my heartfelt thanks to the faculty members of Satakunta University of Applied Science (SAMK), whose collective wisdom and constructive feedback have enriched the depth and quality of this work. Their academic rigor and encouragement have been instrumental in refining the research methodology and shaping the narrative of this thesis.

To my colleagues, classmates and friends who provided support, encouragement, and constructive critiques, I extend my appreciation. Your camaraderie and intellectual exchange have been a source of inspiration, contributing to the refinement of ideas and the overall academic rigor of this work.

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CONTENTS

LIST OF ABBREVIATIONS

BA	Breathing Apparatus
CCTV	Closed-Circuit Television
CO2	Carbon Dioxide
DNV	Det Norske Veritas
EEBD	Emergency Evacuation Breathing Device
FSS Code	International Code for Fire Safety Systems
FTP Code	Fire Test Procedures Code
Halon	Halogenated Hydrocarbon
HFO	Heavy Fuel Oil
HVAC	Heating Ventilating and Air Conditioning
IAS	Integrated Alarm Systems
ICE	Internal Combustion Engine
IMO	International Maritime Organization
LSA	Life Saving Appliances
PPE	Personal Protective Equipment
Ro-Pax	Roll-on/Roll-off Passenger vessel
Ro-Ro	Roll-on/Roll-off vessel
SOLAS	Safety of Lives at Sea
STCW	The International Standards of Training Certification and Watchkeeping
UV	Ultraviolet

1 INTRODUCTION

Fire Safety onboard the ship is of paramount importance, therefore fire safety should be one of the safety drills which should be considered and taken seriously, because the well-being of the crew members, Passengers, Cargo, and the vessel it itself depends on the level of safety training of the crew. Life at Sea is not the same as life at onshore, at sea there is no where you can run to if fire breaks out, the working environment at sea exposes seafarers to danger. Effective fire drills and robust protection measures are essential components of maritime safety.

The purpose of this thesis is to critically analyze the effectiveness of fire drills and protective measures onboard ships, with a particular emphasis on improving fire safety standards in the maritime industry. The implementation of severe regulations and guidelines, such as those specified by the International Maritime Organization (IMO) and the International Convention for the Safety of Life at Sea (SOLAS), emphasizes the need of maintaining high levels of fire safety onboard ships. These requirements require regular fire drills, intensive training programmes, and the installation of advanced fire detection and suppression systems.

Regular onboard safety drills are an integral aspect of every vessel's safe performance. Safety training improves crew preparedness, teamwork, and practical skills required in real-world emergencies. Shipowners and masters are required by maritime law to organize and execute safety drills at regular intervals. (Rots, 2019, p. 1.)

Everyone onboard is responsible for keeping the ship safe from fires. Not only must they ensure that the ship is appropriately safeguarded to avoid catastrophic financial losses to the organization, but they also have a moral commitment to protect the crew members' lives from the devastating repercussions that a fire can have on them. (Cahill, 1990, p. 60.)

2 BACKGROUND OF STUDY

The subject of fire drills and protection is of outmost importance to everyone planning to take up a career in the maritime industry. This is one of the reasons why every person that goes at sea as an employee regardless of their level of education must undergo safety courses which includes firefighting. Fire drills are one of the safety drills which is mostly considered because it can cause catastrophic impact to both the ship, crew, and cargo onboard (Cahill, 1990, p. 8.)

Different types of vessels have different arrangements of safety drills, for example on passenger ships the drills are conducted on a weekly basis, on other ships drills are conducted if the is a crew exchange of up to 25 percent. On cargo ships drills are conducted on monthly basis, and the duration of each training/drill varies based on the scenarios, but the crew members execute the evolution as if it is a real situation. (MNZ consolidation, 2022, p. 6-7.)

The drills are conducted differently on different ships, one most interesting and sophisticated drill which was conducted onboard MV Finnsea was based on theory, the chief engineer created a series of questions instead of doing the practical training for the fire drills. (MNZ consolidation, 2022, p. 6-7.)

It was a way of assessing the crew members to see if they can still remember the theory and ideas of firefighting evolutions. More theoretical drills were arranged in a different way. The crew gathered at the mess room, on a bridge or a muster station. The crew members demonstrated competence in their duties and responsibilities as everyone described their duties/rolls according to the muster list in different emergency situations (ELBAS, n.d., p. 1).

The crew members were always informed about the drills a day before the actual training day. The chief engineer and the second navigation officer (safety officer on board) plan the scenarios of the drill well in advance and include various situations, every month’s drill had different scenarios, location, and the whole evolution. (MNZ consolidation, 2022, p. 10.)

The drills were as realistic as possible, with participants using a variety of Personal Protective Equipment (PPE), lifesaving appliances, and effective communication tools. Smoke generation equipment and fake training mannequins were also used (ELBAS, n.d., p. 3).

The whole crew members participated in a debriefing after the drill had been performed onboard the ship. The debriefing is a platform that evaluates the overall effectiveness of the drill, areas for improvement, concerns about one's roles and obligations, and remarks concerning equipment, leadership, and resources were all discussed. (MNZ consolidation, 2022, p. 23)

To sum up, there are numerous approaches and methods for incorporating required drill requirements into routine daily life and operations on board. Variables that make it difficult to adequately organize and conduct effective drills are as follows: excessive workload, frequent crew rotation from ship to ship, and crew attitudes, these are a key part of ineffective training (ELBS, n.d., p. 9.)

Nowadays, merchant shipping is a highly competitive economic sector. Many new players enter the market and fail. Shipping firms strive to cut costs while increasing earnings to survive and thrive. The number of crew members onboard rarely exceeds the amount specified in a minimum safe manning certificate. Excessive working hours, a wide diversity of duties, and tiredness are well-known industry stumbling blocks. (Dragomir & Uterureanu, 2016, p.1.)

It is very well known that on board, the emphasis is always on activities linked to quick and effective commercial operations, such as navigation, cargo loading and unloading, and, to a lesser extent, ship maintenance. Safety matters, including training, are frequently regarded as irrelevant to usual activities. Therefore, the purpose of carrying out any kind of drill on the ships is to make the crew acquainted with various procedures to be followed during emergency situations. It is also a way to make the ship personnel acquainted with the equipment and methods that are to be used during an emergency. (Dragomir & Uterureanu, 2016, p.1.)

2.1 Research problem and question.

Fire drills can also include actions targeted towards increasing life safety in the event of a tragedy. Preparedness is often thought to include activities aimed at improving response actions and coping abilities.

Research problem: A lack of skills, knowledge and lack of constant fire drill practices contributes to the delay of the crew members preparedness in response to fire crisis and fire prevention and this can cause catastrophic damage to property, sounding and even cause loss of life.

Validated research question: to what extent do safety drills contribute to the crew members' preparedness for real emergencies?

2.2 Research delimitations

Different approaches and perspectives on safety onboard apply to all types of drills, such as entry into an enclosed space, abandon ship, security training, emergency steering, and so forth. With a few exceptions, the quality of the various safety drills is consistent within all ships. This thesis focuses on only one type because the study would be far too large otherwise. For a variety of reasons, fire drills are an appropriate subject for investigation. (Rots, 2019, p. 2-3).

To begin with, fire drills are critical for safety. Quite often, fire or explosion events, if not managed quickly and with excellent teamwork, have serious repercussions, such as huge damage to the ship, cargo, and the environment, as well as injuries and fatalities (Rots, 2019, p. 2-3).

Second, fire drills must be done at regular intervals. As a result, there is a better potential for continuous development of procedures and techniques used. Moreover, there are numerous fire extinguishing systems and equipment to study and practice with. A variety of firefighting equipment may be used in training. Finally, because fire hazards and fire threats onboard vary, there are many different situations that can be practiced in fire drills. (Rots, 2019, p. 3.)

3 FIRE TRAINING

3.1 Objectives of training

Fire training is of great importance on ships. It helps the ship's crew to understand the basics of fire prevention and to prepare the crew for any potential emergency situations brought on by a fire on board (Μακεδονια, n.d.-a, p.17). It familiarizes every crew member with the duties and responsibilities they will need to complete in the event of an actual emergency. Moreover, it instructs the personnel on the proper use of firefighting equipment, including Self-contained breathing Apparatus (SCBA), various fire extinguisher types, CO2 flooding systems, Neil Robertson Stretchers, Inert Gas Systems, fireman's gears, life jackets, sprinkler systems (Μακεδονια, n.d., p. 17.)

Furthermore, it assists the crew in understanding the procedures for operating a specific firefighting system as well as the precautions that must be taken prior to operating the equipment. For example, there are certain mandatory steps that must be completed prior to starting the CO2 fire-fighting system for the engine room. It also familiarizes the crew with the location of emergency escape routes that would be used if a specific area of the ship was inaccessible (Nolan, 2019, p. 137.)

It is stated that fire drills acquaint the crew with the company's fire and safety policies, significant information on personal safety and sea survival, current safety circulars and marine notifications, and ship firefighting equipment and preventative measures. (Zhang, 2000, p. 4.)

It is highly crucial that fire drills are carried out in a realistic manner to keep the crew aware of the problems that may emerge during a fire onboard. (Zhang, 2000, p. 4).

3.2 Training personnel.

Crew members master their unique skills in firefighting techniques, missing person searches, and medical support throughout repetitive drills. They learn how to use personal protection equipment as well as how to handle firefighting systems and appliances while considering their skills and limitations. (Cahill, 1990, p. 20.)

3.3 Preparing crew for real emergencies.

Regardless of age, gender, experience, or training, emergencies always produce varying degrees of stress. Stress is a natural reaction that encourages people to respond in new situations, this relates to the psychological component of human conduct. These are not normal conditions, they are often terribly dangerous, the situation is often unpredictable, and it can grow quickly, necessitating prompt decisions and acts. (McMillan, 2006, p. 2).

People behave differently in an emergency than they do in everyday life, and their actions are not always reasonable and effective. Fire exercises enable the development of habits of logical behavior and sensible actions in the event of a real fire. (McMillan, 2006, p. 2).

3.4 Improving communication and teamwork.

Drills are a great technique to improve cooperation between the crew members in the event of an emergency. Participants learn how to effectively relay critical information about the issue. They coordinate their efforts and assign duties to get better results. Drills aid in identifying gaps or overlaps in the duties listed in the muster list and adjusting the document accordingly. (XpressGuards, 2023.)

3.5 Testing firefighting equipment.

It is the responsibility of the fire safety officer to train the crew on how to maintain and repair firefighting equipment. Regular testing and checks are carried out, and to carry out this responsibility, visual inspections are used for most of these assessments. Fire drills provide an excellent opportunity to practice using a variety of equipment, such as firefighting pumps, lines, hydrants, hoses, firemen costumes, and SCBA in real-world scenarios. (Statków, 2022, p. 8-15.)

3.6 Enhancement of contingency plan.

According to the ISM Code, shipping companies must establish contingency plans for initial steps in the event of an emergency on board. The contingency plan is not a fixed document. It should be assessed on a regular basis and based on practical experience. (Nanyang Technological University, n.d., p. 13)

The deming circle management method is an appropriate instrument for such improvement. William Deming, an American engineer, and consultant pioneered the approach. This mechanism is often referred to as the PDCA-Cycle as shown in figure 1 (Plan-Do-Check-Act or Plan-Do-Check-Adjust). First, a contingency plan is created, with objectives outlined. (Nanyang Technological University, n.d., p. 22-23)

The strategy is carried out within a fire drill in the second stage. The third stage is analysis: fire drills allow you to assess the effectiveness of your plan and its relevance to your goals. Corrective actions are incorporated into plans during the final phase. (Nanyang Technological University, n.d., p. 22-23)

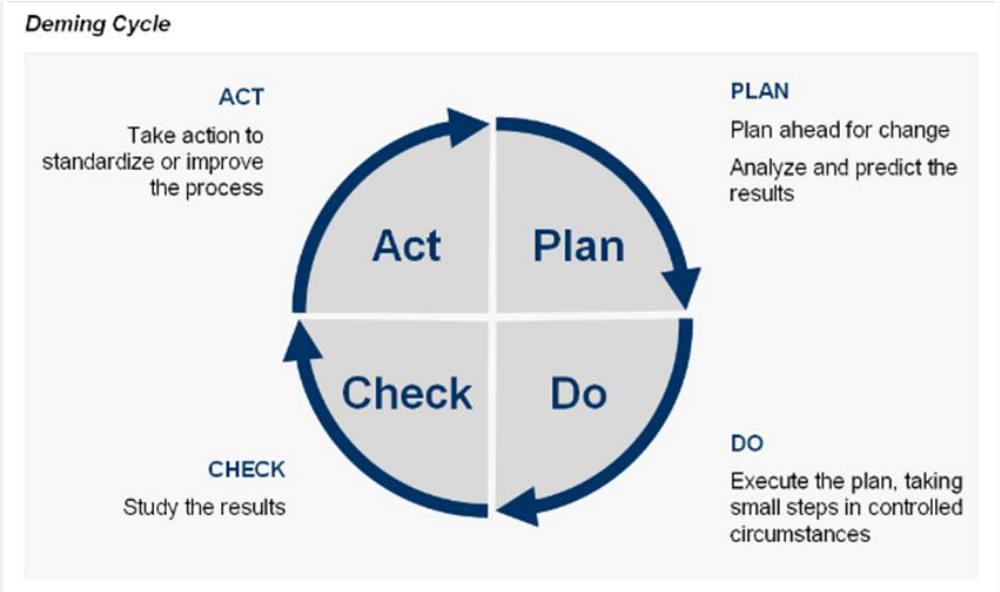

Figure 1. Deming cycle by David Tang, 2016.

With fire drills the PDCA-Cycle is an active phase, it aids in assessing the success of a contingency plan, identifying, and eliminating plan shortcomings, and determining whether the plan is practical, straightforward, and easy to understand. (Nanyang Technological University, n.d., p. 22)

3.7 Training in resource management.

The resources available to cope with a potential emergency on board are always restricted. This scarcity is especially critical for smaller vessels with fewer crew members and less advanced firefighting equipment, as well as LSA. Ship management must be able to display leadership, organize teamwork, maintain consistent communications, and distribute available resources efficiently. A fire drill is an excellent approach to practice these skills. The "What if" method is a useful tool for practicing resource management (Hermansson & Papamatthaiou, 2021, p. 34-35).

The crew must learn how to react in a variety of unforeseen situations, such as "what if the fire pump stops working?" and "what if one of the smoke divers is injured and cannot participate in firefighting?" Another useful piece of information is the drill's time records. Careful timing offers genuine data on the duration of each operation: how long it takes to assemble the crew after the alarm is sounded, how quickly fire parties do fireman costumes and SCBA, how quickly firefighting devices are deployed and prepared for use, and so on. Timing enables the identification of problem regions (Hermansson & Papamatthaiou, 2021, p. 32).

3.8 Fulfilling requirements of legislation.

Finally, fire drills are held because they are required by law. Neglecting legal requirements will result in negative consequences for the ship and the company. Ships may fail annual surveys conducted by classification society or flag administration. The ship may fail an external audit. Port State Control inspections may cause the ship to be detained. To avoid these undesirable outcomes, fire drills must be conducted on schedule and in accordance with formal requirements. Furthermore, drills must be well documented, and a constant thorough record of all training must always be kept on board. (Rots, 2019, p. 19.)

3.9 Chemistry of fire

Fire is a chemical reaction, which consists of a combination of various elements namely oxygen, heat or energy source, fuel, and chemical chain reaction. As a result, this process is known as fire tetrahedron as shown in figure 2. Air is the most common source of oxygen, accounting for 21% of total air on average. It should be noted, however, that oxygen sources may also include oxidizers. Oxidizers are chemical compounds that gather electrons from a fuel and release oxygen when burned. (Ferguson & Janicak, 2005, p. 30.)

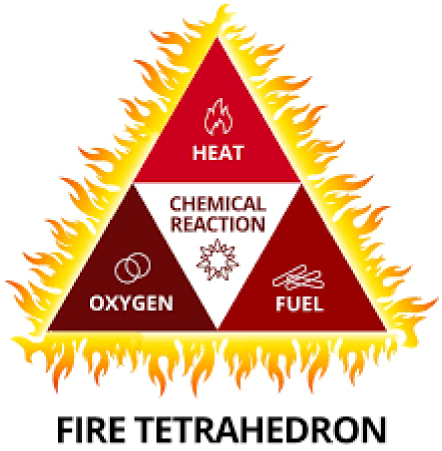

Figure 2. fire tetrahedron by Safeopedia, February 1, 2024.

Fuel is an additional component of the fire tetrahedron. Most fires are caused by carbon and hydrogen-containing fuel, such as wood, paper, flammable and combustible liquids, and gases. (Janicak & Ferguson, 2005, p. 31.) flammable metal, such as aluminum or magnesium, is another possible fuel. The fuels are categorized as follows for fire extinguishment purposes.

Class A: carbon-based products such as wood and paper
Class B: flammable gases and liquids
Class C: combustible materials where electricity may be present.
Class D: combustible metals, such as aluminum, magnesium, titanium, and zirconium
Class K: liquid cooking media (Janicak & Ferguson, 2005, p. 31.)

Each fuel classification has its own symbol as shown in figure 3 below. Fire extinguishers are one type of equipment that makes use of these fuel-classification symbols. Moreover, chemical chain reaction is another element to the fire tetrahedron. This chemical chain reaction occurs within the material itself when the fuel is broken down by heat, producing chemically reactive free radicals, which then combine with the oxidizer. (Janicak & Ferguson, 2005, p. 31.)

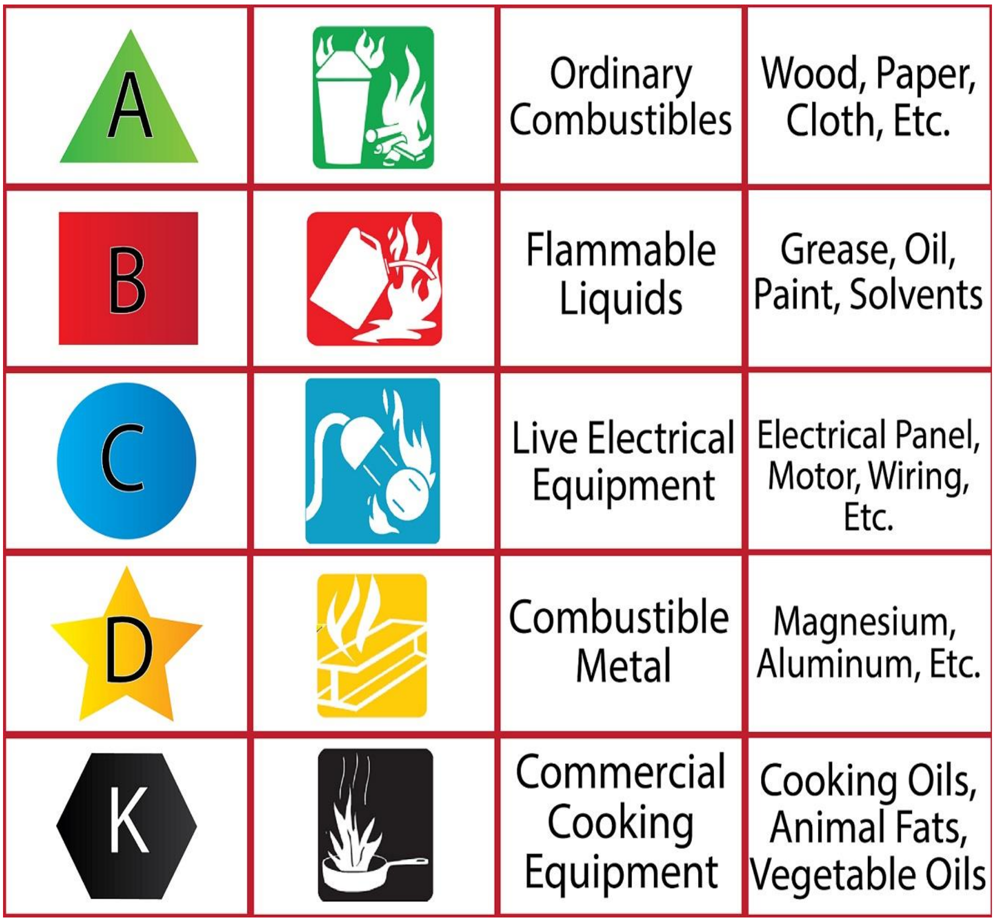

Figure 3. Classification of fuel by FirePro safety solutions, N.D.

4 SAFETY ONBOARD

While the frequency of fire incidents may be relatively low compared to other maritime accidents, they are nonetheless recognized as significant contributors to such incidents due to the substantial damage they can cause. Prompt detection of fires and addressing one or more of the conditions necessary for combustion before a fire fully develops are crucial steps towards successful extinguishment (Nylander, 2021, p. 8).

> SOLAS 74 Chapter II-2, regulation 2 provides functional requirements for fire protection of the ships:
>
> • Division of ship into main vertical zones by thermal and structural boundaries.
> • Separation of accommodation spaces from the remainder of the ship by thermal and structural boundaries.
> • Restricted use of combustible materials.
> • Detection of any fire in the zone of origin.
> • Containment and extinction of any fire in the space of origin.
> • Protection of means of escape or access for firefighting.
> • Ready availability of fire-extinguishing appliances.
> • Minimization of possibility of ignition of flammable cargo vapor (Nylander, 2021, p. 8.)

Onboard fire protection comprises three main categories: structural fire protection, fire detection, and fire suppression. Structural fire protection, categorized as passive protection, aims to prevent fire outbreaks, and limit their spread. In contrast, fire detection and fire suppression, considered active fire protection, focuses on early detection and extinguishment of fires. (Zhang, 2000, p. 2-3.)

4.1 Fire alarm

The primary and most critical step in responding to a fire is to promptly identify it to initiate extinguishing procedures while the fire is still in its incipient stage. Fire alarm systems are indispensable for fire control and are specifically addressed in SOLAS chapter II. (Nylander, 2021, p. 9).

> The fixed fire detection system shall be capable of rapidly detecting the onset of fire and after being installed, the system shall be tested under normal ventilation conditions and shall give an overall response time to the satisfaction of the Administration. When a detector recognizes the fire, the system shall initiate a visual and audible fire detection alarm signal at the control panel and indicating units. The alarm signal should include information about the active detector or at least the active section. (Nylander, 2021, p. 9.)

4.1.1 Fire sensors

The International Code for Fire Safety Systems (FSS Code) authorizes the utilization of detectors that respond to heat, flames, smoke, or other combustion by-products, either singly or in combination. Placement of detectors is crucial for optimal performance, with the FSS Code detailing various requirements and restrictions regarding their installation. (Avazov et al., 2023, p. 3)

Heat detectors are suitable for environments where alternative detectors might trigger false alarms due to contamination or elevated ambient temperatures. They are restricted to compartments where fire propagation is contained, and the heat emitted from the fire can reach the detector. Generally, this specific type of point heat detector is susceptible to disturbances from airflows generated by ventilation systems or fans, resulting in delayed response prior to the emergence of flames from a fire. (Avazov et al., 2023, p. 3)

Bimetallic contact serves as the predominant sensing element in heat detectors. When the ambient air temperature surpasses a predefined level, the M-detector is triggered, causing the mechanical bimetallic strip to flex and either close or open the circuit. Differential thermal detectors (D-detector) activate an alarm in response to a sudden increase in ambient air temperature. The Differential Maximal heat detector (DM-detector) combines features of both the D and M detectors. (Zhang, 2000, p. 37.)

The FSS Code stipulates that the maximum coverage area per heat detector is 37 square meters. Additionally, it sets the maximum distance from bulkheads at 4.5 meters, with a requirement that the distance between detectors must not exceed 9 meters. (Leroux et al., 2018, p. 32-33)

Due to their inability to detect smoldering fires, the FSS Code mandates the use of flame detectors alongside other fire detection devices. Flame detectors are deployed in open spaces with tall ceilings or extensive ventilation, where conventional detectors may struggle to detect smoke or heat generated by a fire. (Leroux et al., 2018, p. 32-33)

Zhang (2000, p. 38) notes that smoke detectors have the capability to detect slow-developing fires and trigger activation earlier compared to heat or flame detectors. The size of smoke particles varies significantly depending on the material burning and the fire's stage. Smoldering fires generate white, highly reflective smoke with a particle size of 0.01 μm, while fully developed fires produce dark, nearly opaque smoke with a similar particle size. Hence, careful consideration is essential to determine the most appropriate detector for each protected area. (Leroux et al., 2018, p. 6)

4.1.2 Closed-Circuit Television Monitoring

The primary benefit of employing a closed-circuit television (CCTV) system for fire prevention, as outlined in the report on detection systems in open ro-ro and weather decks, lies in its ability to validate the existence of a real fire while a fire alarm is activated. Given the frequent occurrence of false alarms, it is imperative to confirm the presence of a fire before initiating fire suppression measures. Compared to conventional protocols where a fire patrol is dispatched to verify the alarm's location, CCTV confirmation can significantly save crucial time. (Sonali et al., 2016, p. 49-52)

Another advantage of employing a CCTV system is the possibility of confirming the activation of a fixed fire extinguisher, thereby enhancing situational awareness. With the ability to record, the CCTV system enables the identification of the ignition source. Even in scenarios where the area is obscured by smoke and the camera captures a smoke-filled image, the ignition source can still be identified through the rewind function of the CCTV system. (Valikhujaev et al., 2020, p. 2.)

According to Nylander's research on detection systems for open ro-ro and weather decks, CCTV detection systems emerge as a promising innovation for detection purposes. There exist three varieties of video detection system technologies. When camera resolution meets specified criteria, a smoke or combined smoke and flame video detection system can be incorporated into an existing CCTV system. This system operates on software that evaluates the CCTV camera feed, making it most practical in well-lit areas; however, it may generate false alarms due to reflections or moving shadows. (Nylander, 2021, p. 12.)

Flame video detection systems can employ cameras specially tailored for the purpose or be integrated into existing CCTV systems provided the camera resolution meets the required standard. In contrast to smoke video detection systems, this system demonstrates a reduced false alarm rate. Past applications in the oil and gas sector indicate its resilience to dust, salt, and moisture, rendering it suitable for maritime settings. (Valikhujaev et al., 2020, p. 2).

4.1.3 Fire watch

According to SOLAS II-2 7.8, passenger vessels with over 36 passengers are required to have a sufficient fire patrol system. Each fire patrol member will be equipped with a walkie talkie and must undergo training to become acquainted with the ship's layout and the location and operation of essential equipment. In certain specialized category contexts, a continuously monitoring fire patrol may substitute for a fixed fire detection system. (McGregor et al., 2021, p. 5).

Research further states that fire detection based on data from ten fire incidents reviews, reveals that fire patrol or personnel discovered three fires before fixed fire detection systems. Given their proximity to the fire source, fire patrols can promptly initiate the first response and extinguish fires in their initial stages. (McGregor et al., 2021, p. 5).

4.2 FIRE SUPPRESSION SYSTEMS AND TECHNIQUES

Once the alarm has been confirmed as genuine, it is appropriate to proceed with extinguishing the fire. There are various fire suppression systems available in the global market. According to the FSS Code issued by the IMO, fixed fire extinguishing systems are classified based on their operational principle as follows:

- Fixed gas fire extinguishing systems
- Fixed foam fire extinguishing systems
- Fixed pressure water-spraying and water-mist fire-extinguishing systems
- Auto sprinkler, fire detection and fire alarm systems
- Fixed emergency fire pumps
- Fixed deck foam system
- Inert gas system

Research conducted by DNV in 2005, as referenced by Nylander (2021e, p. 13), examined fire incidents in various types of vessels. The findings clearly indicate a correlation between delayed activation of fixed extinguishing systems and significant damage. Deluge systems were generally triggered within minutes, whereas CO2 systems typically took hours to activate. Nylander (2021) further suggested that due to the potential danger of CO2 to humans, the delayed deployment of CO2 systems may be attributed to concerns about potential loss of human life. (Nylander, 2021, p. 13.)

4.2.1 Inert gas fire suppression systems

Fixed gas fire suppression systems utilize a gaseous substance to extinguish fires, either by reducing the oxygen levels or disrupting the chemical reaction. These systems are preferred in areas such as technical rooms with electrical appliances, where traditional extinguishing agents like water, foam, or powder could cause significant damage to electrical equipment. (American Bureau of Shipping, 2005, p. 54.)

The FSS Code outlines guidelines for the construction of fixed gas fire suppression systems. This fire suppression agent must be kept outside away from the area being protected, this is because it might leak and cause harm to humans, that’s why spaces accessible to personnel must be equipped with audible and visual alarms. The extinguishant is discharged into these spaces through discharge pipes and nozzles. Moreover, automatic emission of gaseous fire control chemicals is not permitted. (Nylander, 2021, p. 14.)

The use of halogenated hydrocarbon (Halon) extinguishant has been banned since the year 2000, due to its role in stratospheric ozone depletion. While the market offers some gas mixtures as alternatives, they typically require a larger volume compared to Halon systems, potentially leading to storage challenges. Following the prohibition of Halon systems by the IMO, the FSS Code now specifies only three gaseous fire extinguishing agents for fixed fire suppression systems, namely carbon dioxide, steam, and equivalent fixed gas fire suppression systems for machinery spaces and cargo pump rooms. (American Bureau of Shipping, 2005, p. 67).

Carbon dioxide (CO2) serves as a highly effective fire suppression agent without generating any harmful byproducts. Its primary method of extinguishing fires involves smothering, with its cooling capacity contributing minimally to its overall efficacy. The cooling effect varies depending on temperature, with the cooling potential of a portable CO2 fire extinguisher, for instance, being only 149 kJ/kg (American Bureau of Shipping, 2005, p. 54).

CO2 proves ineffective in combating smoldering fires where oxygen is present in the burning material. While the majority of flame fires are extinguished when oxygen levels drop to 12-15%, certain substances can continue to burn at even lower concentrations. To achieve a CO_2 concentration of 15%, it is necessary to introduce 0.06 kilograms of CO_2 per cubic meter of air. However, CO_2 concentrations exceeding 10% pose health risks to humans and may result in fatalities. (McGregor et al., 2021, p. 15).

Numerous arrangements need to be completed before the activation of the CO_2 system, often leading to launch durations exceeding 15 minutes. Due to the hazardous nature of elevated CO_2 levels and the potential for fatalities, evacuation of the protected area is imperative. If the room lacks airtightness, the system's effectiveness will be compromised, necessitating the closure of all fire dampers, fire doors, and other openings. (McGregor et al., 2021, p. 15).

As outlined in SOLAS regulations, any openings that could allow air to enter or gas to escape from a protected space must be equipped with remote closure capabilities accessible from outside that space. It is required to shut down all combustion engines to prevent gas losses, and failure to do so will result in automatic emergency shutdowns when oxygen levels decrease. (Nylander, 2021, p. 15.)

Ship engines can be segregated into several rooms with different fire zones to increase redundancy. Even if one of the engine rooms has a decreased oxygen level, the ship's electrical generation and navigation capacity are maintained in the event of a fire. One approach, which is also employed on navy ships, is to build combustion air ducts for engines straight from the outside (Holsting, 2009, p.95-96).

Fixed steam fire-extinguishing systems were mostly installed on steamships with large boilers. Smothering is the primary way of extinguishing steam by removing oxygen from the air. Fixed steam fire-extinguishing systems require a considerable amount of steam and have the same drawbacks as water. SOLAS does not encourage the installation of stationary steam fire extinguishing equipment. (Zhang, 2000, p. 47.)

4.2.2 Foam discharge fire suppression systems

High expansion foam systems are well-suited for large, enclosed spaces requiring swift foam deployment. These systems saturate the protected area with foam, preventing air from reaching the fire and serving as the primary method of extinguishment. Furthermore, the foam acts to isolate combustible materials from the fire. Additionally, as the foam is generated using water, it provides a cooling effect upon contact with the fire and subsequent vaporization. (Nolan, 2019, p. 138.)

The FSS Code stipulates precise criteria for fixed foam fire extinguishers in machinery spaces, cargo areas, and cargo pump rooms. These systems must be operable manually and engineered to achieve the necessary foam discharge rate within one minute of activation, with the capability to fully saturate the designated area within ten minutes. If the system draws air from outside the protected space, provisions must be made for ventilation to mitigate overpressure and ensure a consistent inflow of air while the space is being filled with foam. (Nylander, 2021, p. 17.)

Enclosed air foam systems eliminate the need for ventilation systems or overpressure openings by recirculating air within the protected area. These systems are simpler and more adaptable to install and are employed in confined spaces such as engine rooms, necessitating the use of specialized foam concentrate that is resistant to combustion gases and high temperatures. (International Maritime Organization, 2007, p. 11.)

4.2.3 Water-based firefighting systems

Water remains the predominant fire suppression agent due to its effectiveness, affordability, eco-friendliness, and universal availability. Water employs three primary methods for extinguishing fires. The foremost technique involves cooling, whereby water evaporation enables it to absorb more heat. When water is dispersed in fine droplets, it evaporates more rapidly, enhancing the efficacy of fire suppression. As water evaporates, its volume expands, displacing an equivalent amount of air and leading to elevated room pressure, which inhibits the inflow of fresh air and reduces oxygen levels. Moreover, small water droplets and mist can obstruct the transfer of heat radiation, thereby preventing flames from spreading to unignited materials. (Hagen & Witloks, 2018, p. 33.)

Water mist possesses characteristics that contribute to its effectiveness in extinguishing fires. These properties include rapid cooling through the absorption of latent heat during evaporation, displacement of oxygen through the creation of a significant amount of water vapor, and the formation of drifting fog that acts as a barrier, effectively smothering the fire (Hagen & Witloks, 2018, p. 33.)

4.2.4 Sprinkler fire protection systems

An automatic water sprinkler system integrates an automatic fire detector, fire alarm, and fire suppression mechanism. The system consists of several sprinkler heads strategically placed throughout a protected area. It is divided into sections, with the FSS Code prescribing a maximum number of sprinkler heads per section. (International Maritime Organization, 2007, p. 15-16.)

“Every sprinkler head should have the ability to distribute 5 liters of water per square meter per minute; however, this volume of water is not enough to extinguish liquid fires”. (Della-Giustina, 2014, p. 128.)

During a fire incident, a quartzoid bulb within the sprinkler head detects an increase in temperature and ruptures. Upon rupture, water is released from the sprinkler head, initiating the extinguishing process. The section valve detects a decrease in pressure within the section pipe, triggering an audible and visual alarm at the bridge or a continuously manned central control station. (Della-Giustina, 2014, p. 128.)

4.2.5 Fire rescue personnel

Firefighters play a crucial role in ship fire control, acting as proficient mobile teams capable of extinguishing fires wherever needed. They can assess the fire's status and enhance the situational awareness of those overseeing fire management. The quantity of firefighters varies based on the ship's size and type, but all seafarers receive instruction in firefighting principles, and regular fire drills are conducted onboard. The Standards of Training, Certification, and Watchkeeping for Seafarers (STCW) outline the necessary safety training requirements. (Nylander, 2021, p. 20-21.)

4.2.6 Fire Safety Systems and Protocols

The ships are properly ventilated through a network of supply and exhaust air ducts. Multiple fans generate airflow within these ducts, with many now featuring frequency converters and being managed by computer-based programs. Fire detection systems can be configured to deactivate the fans in the compartment where the alarm is triggered. (Nylander, 2021, p. 21).

Fire doors and dampers are installed to inhibit the spread of fire between different fire zones. As per SOLAS regulations, these components must be equipped with local closing panels featuring indicators to show the status of the door or damper. Additionally, each fire zone must have a remote shutting panel located in the fire control center. Given their electrical operability, both systems can be interconnected and managed via a computer-based program. (Nylander, 2021, p. 21).

Fires can generate substantial smoke volumes, requiring extraction to mitigate adverse effects like decreased visibility, toxicity, elevated temperatures, and explosion hazards. The primary objectives of employing smoke control systems are to ensure the clarity of escape routes. Since unmanned vessels do not have enough crew members to be doing rounds, all fire doors are always kept closed during the voyage, especially after hours. While the fire dampers can be systematically connected to the alarm system so that if the fire alarm sounds it closes automatically in that compartment (Babrauskas & Grayson, 1992.)

4.3 Fireproofing systems

Structural fire protection is categorized into four fundamental principles: prevention of fire initiation aboard the vessel, partitioning of the ship into primary vertical zones via thermal and structural barriers, isolation of accommodation areas from the remainder of the vessel through thermal and structural barriers, and safeguarding access routes as avenues for firefighting and escape. (Zhang, 2000, p. 26.)

SOLAS outlines rules regarding shipbuilding materials and restricts the use of combustible materials to mitigate the risk of fire incidents. Materials supplied to ships must adhere to the requirements of the Fire Test Procedures Code (FTP Code). The objective of the FTP Code is to ensure that materials possess an appropriate calorific value and do not release excessive smoke or harmful substances in the event of a fire. (Nylander, 2021, p. 25.)

> To contain a fire in the space of origin, SOLAS has set requirements for division of a ship into fire zones. Ships shall meet following functional requirements:
>
> • the ship shall be subdivided by thermal and structural boundaries.
>
> • thermal insulation of boundaries shall have due regard to the fire risk of the space and adjacent spaces.
>
> • the fire integrity of the divisions shall be maintained at openings and penetrations. (Nylander, 2021, p. 25.)

SOLAS outlines guidelines for escape routes to ensure the safe evacuation of both crew and passengers. These routes are also accessible by firefighters to reach the fire location. These regulations differ based on vessel type; every ship is required to have at least two escape routes. These escape routes must adhere to A class standards. (Zhang, 2000, p. 27.)

5 REGULATORY BACKGROUND

5.1 SOLAS

Fire drills can be considered as a safety measure and are aligned with regulations such as The International Convention for the Safety of Life at Sea (SOLAS), which was initially formulated in 1914, officially approved in 1974 and implemented in 1980. SOLAS was created because of the Titanic disaster. SOLAS is widely recognized as the primary international treaty governing the safety protocols for all commercial vessels. (Hermansson & Papamatthaiou, 2021, p. 16.)

The SOLAS Convention's goal is to regulate and impose minimal safety requirements for ship construction and operation, the compliance of which may be confirmed by third parties such as flag states and port state authority. Compliance with the SOLAS Convention standards can be accomplished more specifically through surveys, audits, or inspections, as well as the renewal and issuance of appropriate Certificates (SOLAS Chapter I, 1974). In terms of ship building, the SOLAS agreement establishes basic criteria, such as requiring passenger vessels to have watertight compartments to ensure that the vessel remains afloat in the event of a significant catastrophe (International Maritime Organization, 1974, p. 35-45.)

The convention also addresses issues such as fire protection, detection, and firefighting equipment. SOLAS Chapter II outlines key principles, including the importance of promptly containing and extinguishing fires at their origin and ensuring access to firefighting gear and appliances. (International Maritime Organization, 1974, p. 35-45.)

The regulation also mandates that crew members undergo comprehensive training in fire safety, covering aspects such as understanding the ship's layout, identifying the location, and utilizing Emergency Escape Breathing Devices (EEBDs), as well as familiarizing themselves with the fire-fighting systems and equipment present on board. This training should also entail specific guidance on crew members' responsibilities during a fire crisis. The ship's readiness for fire emergencies must be upheld through the presence of well-prepared fire-fighting teams. Regular onboard training sessions and drills should be scheduled and implemented to sustain the operational readiness and expertise of these teams, as well as to pinpoint areas that require enhancement. (Rots, 2019, p. 9.)

Moreover, SOLAS Chapter III deals with life-saving equipment such as lifeboats and life jackets, while Chapter IV focuses on radiocommunications, facilitating the determination of the vessel's precise location after an accident. Chapter V deals with navigational safety, encompassing services like ice patrols and vessel routing, alongside regulations mandating the presence of Voyage Data Recorders (VDRs) and Automatic Identification Systems (AIS) on all vessels. The data retrieved from VDRs, and AIS is typically analyzed following incidents such as fires, collisions, and groundings to ascertain the causes of the accidents and the sequence of events leading up to them. (International Maritime Organization, 1974, p. 35-45.)

In addition, chapter VII of the SOLAS Convention includes regulations relating to the carriage of dangerous goods, such as packing, labeling, and documentation requirements, and refers to the required adoption of the IMDG Code (International Maritime Dangerous Goods Code) (International Maritime Organization, 1974, p. 35-45.)

These restrictions may also be relevant in terms of fire safety due to the presence and carrying of explosive and/or poisonous commodities that may necessitate specific handling to avoid mishaps, such as overheating. Moreover, it is stated that there are provisions in Chapter IX for the required adoption of the ISM Code (International Safety Management Code). (Hermansson & Papamatthaiou, 2021, p. 16.)

5.2 STCW convention

The International Convention on Standards of Training, Certification, and Watchkeeping for Seafarers, or STCW Convention, was adopted by the IMO in 1978 and went into effect in 1984. The STCW Convention was the first to establish global minimum requirements for seafarers' training, certification, and watchkeeping, to standardize the applicable legislation, which previously varied from country to country. (International Transport Workers' Federation, 2010, p. 11-43.)

The convention comprises sections concerning the roles of the master and various departments aboard the ship. The STCW Code elaborates on aspects of the STCW Convention, with Part A being obligatory and Part B serving as advisory guidance. (International Transport Workers' Federation, 2010, p. 11-43.)

Furthermore, another key feature covered by the STCW Convention is the obligation for the crew to have a reasonable opportunity to become familiar with the ship's equipment and operating procedures. This criterion is the responsibility of the ship's owner and/or the Master and can be met through an introductory program (International Transport Workers' Federation, 2010, p. 11-43.)

The provisions of the Certificate of Competence vary according to the seafarer's capacity (e.g., Master, Chief Mate, Chief Engineer, OOW, Radio operator, etc.), the area limitation (e.g., near coastal or no limitation), and the tonnage or propulsion power limitation (e.g., less than 500gt, less than 3,000gt, 750 kw to 3,000 kw, etc.) (International Transport Workers' Federation, 2010, p. 29-43.)

The Certificate of Proficiency rules, on the other hand, differ for employees working on different types of vessels (e.g., tankers and passenger ships) and for seafarers with duties related to safety, security, and pollution prevention (e.g., safety and care of persons or cargo). Finally, when discussing further documentary proof, records showing participation in safety drills, basic safety training, and familiarization training may be mentioned (International Transport Workers' Federation, 2010, p. 29-43.)

5.3 ISM Code

The International Safety Management Code (ISM), which entered into force in 1998, is part of SOLAS and mandatory for all vessels with a gross tonnage in the range of 500 and above. The ISM Code was implemented due to the capsizing of the Herald of Free Enterprise in 1987, in the port of Zeebrugge (Rots, 2019), with poor shore and safety management being a major cause of the tragedy (Anderson, 2015, p. 3.)

Moreover, another reason for the formation of the ISM Code was that the cause of many disasters has been recognized as 'human mistake'. As a result, the ISM Code intends to strengthen the shipping industry's Safety Culture by enhancing procedures and decreasing human errors, to minimize injuries or loss of life, as well as damage to property and the environment. (Anderson, 2015, p. 3.)

The regulation requires shipping companies to create Safety Management System manuals and to pass auditions conducted by national administrations or Classification societies. One of the most important aspects of SMS Manuals is that they include protocols for preparing for and responding to emergency circumstances, as outlined in Section 8:

> Emergency preparedness
>
> 8.1 The Company should identify potential emergency shipboard situations and establish procedures to respond to them.
> 8.2 The Company should establish programs for drills and exercises to prepare for emergency actions.
> 8.3 The SMS should provide for measures ensuring that the Company's organization can respond at any time to hazards, accidents and emergency situations involving its ships. (Hermansson & Papamatthaiou, 2021, p. 22.)

On Finnish ships, drill schedules are frequently arranged as a drill matrix for the entire year. Because the program is complete, those in charge of the drills just follow the matrix and execute training in accordance with the time frame. (Rots, 2019, p. 14.)

5.4 Important points regarding fire drills on ships

In case over twenty five percent of the crew did not partake in a fire exercise in the month before, a drill must be held within 24 hours of leaving the port. The muster list for the drill should be displayed throughout the ship in easily accessible locations. (INSB class, 2020, p. 1-4).

The list should be kept on the bridge, in the engine room, and in the crew quarters. A clear fire control plan should be adequately deployed in critical spots across the ship. Each crew member should be given clear instructions to follow in the event of an emergency. (INSB class, 2020, p. 1-4).

Each member's responsibilities, as well as the allocated lifeboat number, must be written on separate cards and stored inside/outside the cabin. The emergency drill schedule should be updated to modify circumstances and allow crew members who were unable to attend the prior practice due to their duty to participate. The drill locations should also be modified to allow the crew to practice in different conditions and to prepare them to deal with various sorts of fires such as machinery space fires, accommodation area fires, storeroom fires, cargo hold fires and so on. (INSB class, 2020, p. 1-4.)

The muster station should be close to the departure point and conveniently accessible from both the cabins and workplace. It should also provide adequate emergency illumination. Each area of the ship has a different technique for dealing with emergency circumstances. Training with drills in diverse conditions helps to prepare crew members for all kinds of situations. (INSB class, 2020, p. 1-4.)

Upon joining the ship, each crew member is responsible for learning the location of the emergency muster station. He/she should also understand his/her obligations as indicated in the muster list and be conversant with firefighting equipment. Each crew mess and recreation room should have a training booklet containing instructions and information on life-saving equipment and survival skills. (INSB class, 2020, p. 1-4.)

Each newly recruited crew member must undergo on-board training orientation within two weeks of joining the vessel. This orientation is designed to familiarize them with the operation of personal life-saving equipment and survival crafts, such as lifeboats and life rafts. It is imperative that each crew member executes the drill flawlessly, demonstrating a thorough understanding of their responsibilities and the paramount importance of ensuring the safety of both the vessel and its occupants. (INSB class, 2020, p. 1-4.)

5.5 Guidelines for Successful Fire Drill Implementation

According to STCW standards for competence advanced firefighting necessitates the ability of seafarers to organize and train fire parties. This qualification includes the ability to construct contingency plans for fire emergencies, assign personnel to fire parties, and devise strategies and tactics for fire control in various areas of the ship. (Hermansson & Papamatthaiou, 2021, p. 20.)

The students at Satakunta University of Applied Sciences (SAMK), always attend firefighting courses arranged by school, at WINNOVA Training Centre in Pori which is mandatory according to STCW. They do basic firefighting and advanced firefighting, the training is always intense, functional, and understandable. The students experience different types of firefighting apparatus and appliances. Different scenarios were played out, and participants practiced their firefighting skills individually and in groups, as well as members of fire parties and emergency coordinators.

Due to time constraints, a more theoretical subject of planning fire drills was presented to them briefly. As a result, when mariners are assigned to train fire parties on board a ship, they seek additional expertise in organizing effective fire drills. This information can be obtained in a variety of ways. It is often obtained from personal experience, and personnel in charge of fire safety rely on their own background to prepare drills comparable to those in which they previously participated. Shipping companies may also have ready-to-use exercise scenarios, such as a compilation of exercises for aboard safety drills. (Rots, 2019, p. 16).

6 RESEARCH METHODOLOGY

6.1 Research plan

The purpose of this research was to gather information about fire Protection and prevention onboard a ship, and how to organize fire resources in the maritime industry, especially vessels operating under the finish flag. Moreover, to assess how well the skills learned in the maritime education programme are maintained and advanced in the working environment. (Rots, 2019.)

The research was based on qualitative research approach, where questions were asked from crew members of the vessels, where the author worked as a cadet and did some observations and conclusion. One of the objectives was to find out if there were anomalies between the students in the maritime educational institutes and the people currently working in the maritime industry or at sea.

Furthermore, the research was conducted to analyze the courses and factor that contribute to fire aboard Ships. Another objective was to find ways on how such factors can be prevented to protect the lives of the crew members, properties, and the environment.

6.2 Method selection

In this thesis case study, a research design process was used, because this process will allow one to conduct a more detailed study of the topic in question and it will help one to be able to focus on gaining a holistic understanding of the case.

This method also helps one to use knowledge from previous research papers and make congruent conclusions. Case studies are effective tools for understanding the complexity of a situation, including its temporal evolution, and for examining its contextual factors.

Case studies provide an effective approach to fully understand the complexities of a case, including temporal shifts and contextual circumstances. They offer a valuable means to explore the multifaceted aspects of a case, allowing for an examination of both temporal changes and contextual factors.

6.3 Data collection

Two distinct methodologies are employed for data collection: primary and secondary data. Primary data refers to information gathered firsthand, whereas secondary data comprises pre-existing data that has been collected and analyzed by others. This thesis utilizes both approaches (Ferguson & Janicak, 2005).

Primary data was collected by asking verbal questions to various chief engineers, engineering officers, safety officers onboard and various crew members different finnish vessels named M/V Finneco 3, M/S Pasila, M/V Finnsun and M/V Finnsea.

The respondent’s professional backgrounds in the maritime sector ranged from 4 to 40 years of experience at sea or within the maritime industry. Secondary data was gathered through the review of previous theses, dissertations, government surveys, and prior studies.

7 DATA PROCESSING

The questions were simple and straightforward. The main answering method was verbally in the form of a discussion. This platform proved to be excellent for this purpose and it was easy to handle. The questions were not asked at the same time nor on the same day, instead they were asked from time to time.

The answers were written down by the author as the interviewee was responding. It was very interesting, because it was like a discussion forum. Due to their busy schedules the author had to be very patient with the respondents. All respondents replied in English, so no translations were required.

Vessel type.

This question was created to map out the various types of vessels from which the answers came from. This was done since the results may differ between different types of vessels, even if they are sailing under the same flag, even though the requirements of the 1974 SOLAS Convention must be followed by every SOLAS vessel, regardless of flag or type of the vessel.

All vessels wishing to be recognized as SOLAS vessels must follow the same rules and regulations for fire training exercises. The International Maritime Organization classifies a SOLAS vessel as: “A vessel of 500 GT or more, or any passenger vessel, operating in international waters” (International Transport Workers’ Federation, 2010, p. 11-43.)

Position of the authorized officer to oversee fire drills.

The person responsible for coordinating and executing fire drills on ships typically involves the chief engineer, who receives support from the first engineer. On smaller ships like general cargo vessels, it's more common for 2nd/3rd officers to oversee these drills. This could be attributed to the smaller crews on such ships and the consequent need for a redistribution of responsibilities. Generally, conducting fire drills onboard is regarded as a vital and crucial task, typically entrusted to individuals with higher ranks and extensive experience. Junior officers typically undertake these duties for the purpose of learning and gaining experience, because they are the future of the organization or company. (Santeri, 2021, p. 18)

How often fire drills are conducted on vessels.

As per SOLAS regulations, fire drills must occur weekly for passenger ships and monthly for other vessel types. These frequencies represent the minimum standard, with the expectation for more frequent drills during crew changes. This query seeks to determine if the frequency of fire drills conducted onboard aligns with legal regulations. On general cargo and roll-on/roll-off (roro) vessels, drills are carried out either monthly or, occasionally, every two weeks. These timeframes are in accordance with the requirements set by law. (Wilkman et al., 2016.)

As recounted by a student who served as a cadet on ferries, the situation regarding fire drills on passenger ships (Cruise and ROPAX) appears to be inconsistent. While some vessels adhere to SOLAS regulations by conducting drills weekly, others opt for bi-weekly or monthly schedules. (McGregor et al., 2021, p. 13).

Integrating Fire Drill Planning with Other Emergency Drills.

Fire drills are typically organized by the engine department, while abandon ship drills are for the deck department. Organizing a combined drill requires cooperation within different departments, so that they understand the importance of effective operational planning and workload distribution onboard. (Danish Maritime Authority's guidance, 2002, p. 2).

Some respondents from general cargo and roro vessels stated that they always do combine drills, this is done because it is a requirement for the company. They always start with general safety drills like survival drills, how to don emersion suits and life I jackets then they jump to fire drills after the whole evolution of the fire drills is completed, the scenario changes to black out drill, then it is further concluded by performing abandon ship drill, this is done to simulate a real situation. (Danish Maritime Authority's guidance, 2002, p. 2).

Duration of Fire Drills.

What is the usual duration of a fire drill? This question is intended to assess how much time the crew may spend on fire drills. A realistic exercise should include conceivable activities that could occur in a real-life situation.

The actions that comprise a drill are quite extensive and may include raising an alarm, mustering the crew, donning fireman outfits, detecting the fire or smoke, searching for missing persons, providing first aid in the event of injury, deploying fire hydrants or other firefighting equipment, starting fire pumps, putting out the fire, and maintaining a fire watch after the fire has been extinguished. (Danish Maritime Authority’s guidance, 2002, p. 1).

These actions must be carried out at a moderate pace, quickly but not hurriedly. All dubious or doubtful situations must be clarified. Following the active phase, all equipment utilized must be returned to its regular stowage position, and debriefing takes place.

Most respondents said they do not know the exact time it takes but they do it as swiftly as possible, as if it was in real life situation because in real life the situation may get worse and worse. A proper drill is an extensive event which requires active evolvement of many crew members. Shortcuts and simplifications reduce effectiveness of fire drills. (Danish Maritime Authority’s guidance, 2002, p. 1).

Considerations for Timing Fire Drills.

The purpose of asking what time of day the emergency training exercises were held is to determine how often or rare it was to hold emergency training exercises in less-than-ideal conditions such as low visibility and crew fatigue.

Most of the participants responded that the time of the drill is normally between 14:00 PM to 16:00 PM, while some respondents indicated that the most usual time of day for emergency training exercises was between 0800 PM and 1200 PM. Others indicated that it was between 1200 PM to 1600 PM. (Santeri, 2021, p. 22).

The SOLAS Convention does not require that firefighting training or drills take place at specific times of the day; however, to better the prepare of the crew members with firefighting skills and responsibilities for a real emergency that may occur outside the most common time of the day, training can take place at any time provided it is safe to do so. (Santeri, 2021, p. 23).

Some respondents stated that holding a firefighting training under perfect settings may leave a knowledge gap for crew members when a real emergency happens unexpectedly, such as during the night when the aid of sunshine and other awake crew members is cut off. (Santeri, 2021, p. 22).

It is always up to the captain on how drills are scheduled, and it is necessary to consider aspects such as crew rest intervals and other ongoing tasks on board. Drills in the dark, on the other hand, could better prepare participants for a real emergency. (Santeri, 2021, p. 22).

Notifying the crew about future drills.

This question was asked because the author wanted to ascertain how crew members are informed about upcoming drills. Unannounced drills keep the crew awake and encourage them to be always prepared. If the crew is informed beforehand, they will try to prepare, and such action might affect the order of the day. (Rots, 2019, p. 28-29).

The answers about drills announcement, was answered as follows, some respondents stated that in most cases, participant know about upcoming fire drills in advance a day or two before the drill day.

Some stated that they do not get informed in advance, but the captain makes an announcement on one mike Charlie(speaker) three times example for exercise, for exercise, for exercise, fire, fire, fire, then the crew must react accordingly, nevertheless, such announcements are more common aboard naval ships. (Rots, 2019, p. 28-29).

Effective Drill Scenarios for Emergency Preparedness.

In this question, seafarers were asked if their ships undertake fire drills based on specific scenarios. Preparing and carrying out the practice in accordance with a realistic scenario takes more time, but it is more efficient in terms of crew preparedness than drills that just describe everyone's roles and check the equipment.

Some respondent's stated they do have drills conducted according to scenarios, they normally meet up at the bridge then the chief Engineer and the safety officer brief the crew about the scenario of the drill, this is the time the crew is informed about the type of fire and the location where the fire is taking place, while others have drills which may be described as tabletop exercises, without practical firefighting operations in specific area (McMillan, 2006, p. 11).

Key Components and Procedures in Fire Drill Exercise.

Respondents were asked about routine shipboard operations that typically simulate fire drills. The list contains various activities, including alert and muster procedures, briefing on emergency duties to name a few. It was found that at least two out of every three fire drills involve personnel assembling at designated muster stations upon activation of the fire alarm. (McMillan, 2006, p. 34).

Fire department members don protective firefighter gear, utilize self-contained breathing apparatus (SCBA), or receive instruction and demonstration on SCBA operation. Several fire hoses are connected to hydrants and made ready for immediate use. Subsequently, fire pumps are activated, and the team extinguishes the fire utilizing hydrants and hoses. Prior to or following these procedures, crew members outline their roles in fire scenarios, with explanations or demonstrations provided on the use of fixed firefighting installations such as CO2 or inert gas systems. (McMillan, 2006).

Aside from these basic tasks, every other exercise adds features such as the usage of hand-held radios and an explanation by the crew of which fire doors, dumpers, vent inlets, and outlets should be closed in the event of a fire. (McMillan, 2006, p. 34).

Explanation of the use of portable fire extinguishers and EEBD is uncommon. According to the survey, fire drills also lack features such as search and rescue of people from the fire area and medical treatment of victims. About 38% of all training includes searching for missing people, and about 21% of fire drills involve first aid methods. Supplementary equipment is not commonly used aboard Finnish ships, with a few of responders having smoke-generating devices or dummy mannequins. (McMillan, 2006, p. 32).

To summarize, the actions included in a normal fire drill on a Finnish ship are less than what is required for good training. A considerable portion of exercises do not even involve these mandatory procedures mandated by statutory standards, particularly SOLAS. (McMillan, 2006, p. 34).

Essential Components of Post-Drill Debriefings.

Training debriefing is an important aspect of a fire drill, along with planning, preparation, and execution. A thorough debriefing may expose problems in crew performance, as well as a lack of and malfunctioning equipment on board.

Debriefing is a technique for improving contingency preparations. It is critical to allot enough time for post-training communications and to encourage participants to openly express their opinions and recommendations. (Southam, 2020).

Some responders stated that there is no post-fire drill debriefing. While other participants discuss the crew's performance during the drill. Proposals for strengthening emergency procedures and improving firefighting equipment are presented. Supplemental training is a somewhat uncommon issue in debriefing conversations. (Southam, 2020).

Developing Preparedness and Confidence in Responding to Real Emergencies.

This question inquired about the individual's belief in their ability to save an unconscious person trapped in a fire compartment. This, in my opinion, is one of the most significant concerns because it is the reason why we study and train for real-life situations.

The question is whether they believe they have the necessary skills to save an unconscious coworker from a suspected fire compartment in such a timely manner that the victim does not suffer permanent damage to their health or, in the worst-case scenario, die, and in such a safe manner that the rescuer does not become injured or die in the process. This question made the interviewee go mute, while the majority answered that do not be a hero safety first. (Fire Risk Assessment Network, n.d.)

Measures that can improve Fire Drill Efficiency.

In response to the question, what measures onboard your ship could improve the efficiency of fire drills? participants were questioned about feasible actions that could improve fire drills. Most participants provided their ideas for potential changes. The following are the most common notions. (Fire Risk Assessment Network, n.d.)

It's evident that there's a clear demand for improved drill planning to ensure more realistic and diverse scenarios. Recommendations for enhancement include more comprehensive planning, incorporation of larger and more varied scenarios, adoption of different case scenarios for each drill, transitioning from spontaneous to carefully planned drills, and more frequent rotation of scenarios with thoughtful consideration. Additionally, there's a suggestion to introduce full-scale drills to further enhance preparedness. (Fire Risk Assessment Network, n.d.)

Another evident feature is that crew members should properly study their roles in the event of an emergency: know your duties and familiarize yourself with the fire and safety plan, familiarizing one's duties thoroughly, everybody knows their duty. (Fire Risk Assessment Network, n.d.)

There's a demand for drills to be more hands-on and practical. Currently, drills often resemble tabletop exercises where crew members simply discuss their roles. Suggestions include conducting more serious drills that involve action rather than just discussion, prioritizing actual training over mere discussion or demonstration, incorporating greater realism and practice, emphasizing the execution of assigned duties during drills rather than simply following a schedule, and transitioning from demonstration to active participation. Additionally, there's a recommendation for better organization of smoke diving drills, improved training for smoke divers, and quicker donning of firefighter gear. (Fire Risk Assessment Network, n.d.)

Having extra training air cylinders or a replenishing compressor on board is advantageous. Other equipment should undergo regular testing and use. Allocate sufficient time to familiarize yourself with all necessary equipment. Respondents suggested introducing an element of surprise by withholding the timing of the drill and keeping the location of the fire unknown to the crew. (Fire Risk Assessment Network, n.d.)

In conclusion, it is imperative to explore more effective motivation techniques for both crew members and drill organizers. Encouraging active involvement in drills, cultivating positive attitudes, and acquiring skills to motivate older seafarers are essential aspects to consider. Although no specific methods were suggested, one seafarer proposed that experiencing a real accident could serve as a catalyst to enhance participants' motivation for fire exercises. (Fire Risk Assessment Network, n.d.)

Factors that can impact on efficiency of fire drills.

What factors onboard your ship have a negative impact on efficient fire drills? Sailors were asked which elements, in their opinion, compromise the quality of fire exercises. There are no such elements, according to two participants, while the rest did not respond.

While some responses highlighted the following training weaknesses. The most common response is work overload and a lack of time. Safety training is regarded as an added duty rather than as part of the typical working routine.

Respondents stated that the crew is too busy due to ship schedule, lack of time due to cargo operations, and drills are kept as short as possible so that crew can concentrate on their work. The variety and amount of work obligations over long periods of time can lead to weariness. Seafarers had concerns about tired crew making drills a lot sloppier with more mistakes, concerns about interrupting rest time, and fatigue. Shorter responses include lack of time, watchkeeping schedule, normal duties, restricted time, and timetable. (Omar et al., 2023, p. 16).

Furthermore, the crew's attitude. This is the second most common response; respondents valued this factor. The attitude of those in charge of fire drills was stated by respondents, lack of interest from higher ranking officers and ship owners, most of the fire crew are people from the engine room, and they are lazy, lazy chief engineers.

Experienced mariners are another significant group that does not take drills seriously. Usually, it is the older crew members who are uninterested in drills, the older generation of sailors know everything already attitude, older crew members are uninterested in drills. Other similar responses include people who are uninterested in safety issues. (Omar et al., 2023, p. 16).

In addition, in some cases, the people in charge of the fire drills work harder to make the drills relevant. Respondents stated, since we have fire drills quite frequently, the crew does not find the drills interesting (drills are held once a week), and boring drills. (Omar et al., 2023, p. 16).

Furthermore, there were complaints regarding the delayed response of the crew. On certain occasions, the crew's reaction to fire drill alarms was sluggish. When faced with an unexpected fire alarm onboard, significant time may elapse before any action is taken, resulting in a slow mobilization of the crew.

On one ship, frequent false fire alarms created a situation in which all the crew are just waiting for the bell to be silenced and assuming that it is a false alarm (Omar et al., 2023, p. 16).

Significance and Objectives of Fire Drills

The goal of this inquiry was to determine seafarers' perspectives on drill goals and the value of safety training. Most of the questions were vague.

According to popular belief, fire drills should train the crew for real-life crises. Firefighting training is required to prepare and be ready in the event of a fire onboard, or to prepare personnel to act in an actual situation. Drills, according to more precise responses, are required to increase participants' knowledge and practical skills to learn how to put out a fire onboard and locate and evacuate crew members. (Nyankuru, 2017, p. 168).

Drills aim to train the crew members and acquaint them with their respective duties and responsibilities during emergencies. Another objective of drills is to acquaint the crew with the equipment aboard, including its locations, proper usage, and testing procedures. This includes becoming proficient in operating fire extinguishing systems and becoming familiar with all firefighting equipment and systems on the ship. (Nyankuru, 2017, p. 168).

Drills, according to a few participants, are tools for fostering collaboration and good communication, exercises are required to prepare the crew to operate together as efficiently and safely as possible. Furthermore, drills are necessary to improve emergency plans. (Nyankuru, 2017, p. 168).

8 ANALYSIS

8.1 Conclusions

In this validated research study, the author has delved into the critical question of the extent to which safety drills contribute to the preparedness of crew members for real emergencies. Through a comprehensive review of literature and empirical evidence, the author has endeavored to shed light on the efficacy of safety drills in equipping crew members with the necessary skills, knowledge, and confidence to respond effectively in high-stakes situations. (Vukonić et al., 2016, p. 63).

The findings strongly support the assumption that safety drills play an important role in improving crew members' preparedness for real emergencies. These drills provide essential chances for crew members to become acquainted with emergency protocols, practice critical skills and improve their responses to diverse scenarios. Safety exercises simulate real-life events in controlled surroundings, allowing crew members to establish muscle memory, increase coordination, and cultivate a sense of preparedness to deal with unexpected scenarios. (Vukonić et al., 2016, p. 60.)

One of the most significant advantages of safety drills is their potential to reduce panic and confusion during actual situations. Crew members improve their ability to execute emergency protocols calmly and quickly through repeated practice and exposure to simulated circumstances, reducing the likelihood of errors and improving overall safety outcomes. Furthermore, safety drills encourage good teamwork and communication among crew members, encouraging a coherent and coordinated reaction to situations onboard. (Vukonić et al., 2016, p. 64-65.)

Furthermore, safety drills serve as invaluable learning experiences, allowing crew members to identify areas for improvement and refine their emergency response strategies. Debriefing sessions following safety drills offer opportunities for reflection, discussion, and constructive feedback, enabling crew members to learn from their experiences and implement necessary adjustments to enhance their preparedness for future emergencies. (Vukonić et al., 2016, p. 63).

However, safety drills contribute significantly to crew members' preparedness for real emergencies, it is essential to acknowledge that their effectiveness may be contingent upon various factors. The frequency and realism of safety drills, the quality of training resources and facilities, and the proficiency of instructors all play crucial roles in determining the efficacy of these drills. Therefore, ongoing efforts to optimize safety drill protocols, incorporate innovative training methodologies, and provide comprehensive support to crew members are paramount to ensuring their continued effectiveness in enhancing emergency preparedness. (Vukonić et al., 2016, p. 63.)

Moreover, future research should strive to investigate additional aspects of safety drill efficacy, such as long-term skill retention, the impact of cultural and organizational factors on drill effectiveness, and the incorporation of developing technology into drill protocols. We can ensure that crew members are appropriately prepared to respond to the varied range of situations that may arise at sea by constantly refining and updating safety drill techniques based on empirical evidence and best practices. (Vukonić et al., 2016, p. 60-62.)

In conclusion, the findings from this validated research question underscore the critical importance of safety drills in enhancing the preparedness of crew members for real emergencies. By providing crew members with essential skills, knowledge, and confidence, safety drills serve as indispensable tools in safeguarding maritime safety and security. As we navigate an increasingly complex and dynamic maritime environment, the continued emphasis on robust training and preparedness measures remains essential to ensuring the safety and well-being of crew members and the vessels they serve aboard. (Vukonić et al., 2016, p. 64-65).

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