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Fire Safety Training of Crew Onboard

with focus on Fire Drills and Safety Culture onboard Tankers and Ro-Ro / Ro-Pax vessels

Master's thesis in Maritime Management

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Abstract

Fire and explosion onboard vessels is considered to be a major cause of maritime accidents (Baalisampang, Abbassi, Garaniya, Khan & Dadashzadeh, 2018) and this type of accidents appear to be more than twice as mortal (Weng & Yang, 2015). Therefore, the emergency preparedness of crew onboard is crucial (Tac, Akyuz & Celik, 2020) in order to ensure that the crew is equipped with the necessary knowledge and skills. An important component of emergency preparedness onboard is fire safety training and fire drills. Fire safety training and drills are regulated in the SOLAS Convention, the ISM Code and the STCW Convention and associated STCW Code. However, it can be suggested that different factors, such as the Safety Culture onboard, may have an impact on the outcome or quality of fire safety training. This thesis focuses on identifying and analysing what skills are considered important for the crew to obtain through fire safety training and what factors may have an impact on fire safety training onboard. This is done through a comparative analysis between the applicable Rules, Regulations and Theories in conjunction with primarily data collected through interviews with individuals working within the shipping industry. The results from this thesis reveal that the skills which should be obtained can be categorized into three areas; Practical, Theoretical and Social. The factors which deem to have the largest impact on the training carried out onboard is Safety Culture, Leadership and Knowledge. Furthermore, the study identified a gap between the fire safety training carried out onboard and the applicable Rules and Regulations. Based on these results, suggestions are made to improve the fire safety training onboard, according to the factors influencing the training and the skills that are considered most important for the crew to obtain.

Keywords

Safety Training, Safety Management, Maritime Training, SOLAS, STCW, ISM Code, Fire Safety, Firefighting, Fire Prevention, Fire Drills, Safety Culture

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Preface

This thesis was produced as part of the Master's Programme in Maritime Management and has been carried out for the Department of Mechanics and Maritime Sciences at Chalmers University of Technology, based in Gothenburg, Sweden. The topic of this thesis is Fire Safety Training of Crew Onboard with focus on Fire Drills and Safety Culture onboard Tankers and Ro-Ro/Ro-Pax vessels.

The objective of this thesis paper is to identify and analyse what skills concerning fire safety training are considered important and what factors have an impact on fire safety training onboard. This investigation is done in conjunction with the relevant requirements under the applicable Regulations, such as the SOLAS Convention, the STCW Convention and associated STCW Code and the ISM Code and by comparing qualitative data obtained through interviews with shipping professionals.

The thesis was carried out during the spring semester of 2021 by two Master students, Emma Hermansson and Dafni Papamatthaiou. It was supervised by Dr. Martin Viktorelius at Linnaeus University and examined by Johan Hartler at Chalmers University of Technology.

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List of Abbreviations

AIS: Automatic Identification System

BA: Breathing Apparatus

BRM: Bridge Resource Management

DPA: Designated Person Ashore

HSE: Health Safety Environment

ICS: International Chamber of Shipping

IMDG Code: International Maritime Dangerous Goods Code

IMO: International Maritime Organization

ISM Code: International Safety Management Code

ISO Standard: International Organization for Standardization Standard

MARPOL: International Convention for the Prevention of Pollution from Ships

NTS: Non-Technical Skills

Ro-Pax: Roll-on/Roll-off Passenger vessel

Ro-Ro: Roll-on/Roll-off vessel

SMS: Safety Management System

SOLAS: International Convention for the Safety of Life at Sea

STCW Convention: International Convention on Standards of Training, Watchkeeping and Certification for Seafarers

STCW Code: Seafarers Training, Certification and Watchkeeping Code

VDR: Voyage Data Recorder

1. Introduction

Working onboard a vessel is considered a high-risk occupation (Oltedal, 2018), as the working environment exposes the seafarers to risk and stress factors different from those in a shore-based occupation. When accidents such as fire, collision, grounding or flooding occur onboard vessels, medical, firefighting and rescue assistance from shore may be far away (Oltedal, 2018). According to recent studies, fires and explosions onboard vessels are one of the main causes of maritime accidents (Baalisampang, et. al., 2018) and accidents involving fire or explosion are more than twice as mortal (Weng & Yang, 2015). Furthermore, research has suggested that human error remains the leading cause of accidental events onboard and that lack of knowledge and of emergency procedures have a very high percentage of occurrence (Ferreira da Silva, 2015). Therefore, and considering that the onboard personnel must be able to handle situations, such as fires onboard, initially without external on-scene assistance, emergency preparedness and safety training is of crucial importance for seafarers (Tac, Akyuz & Celik, 2020).

One main component of emergency preparedness is onboard training and drills (Tac, Akyuz & Celik, 2020), which enables the crew to practise how to effectively deal with an emergency (Dragomir & Utureanu, 2016). However, safety training onboard needs to be adjusted to the particular needs of the crew and of each vessel type and to be in accordance with the applicable Rules, Codes and Regulations, such as the SOLAS Convention, the STCW Convention and associated STCW Code and the ISM Code. That said, it is evident that the proper training and preparation of the crew for an emergency, such as fire onboard, has a great effect on the outcome of it. This study focuses on identifying what skills are considered important in relation to fire safety training and what factors have an impact on fire safety training onboard, such as the Safety Culture. For answering the research questions, a comparative analysis is done between the applicable regulatory framework and relevant theories in conjunction with primary data collected through interviews with shipping professionals.

1.1 Background

The background of safety training can be first viewed in relation to the applicable Regulations, which will be shortly mentioned in this section of the report and further on presented in detail. The first Regulation with the aim to enable the safety of seafarers (Fukuoka, 2019) was the *International Convention for the Safety of Life at Sea* (SOLAS), signed in 1914 and with the current version adopted in 1974 and subsequently amended further. The SOLAS Convention came in the aftermath of the Titanic disaster in 1912 (Fukuoka, 2019) and is still in force, although it has been considerably amended (Oltedal, 2018) since 1914. SOLAS regulates technical requirements of maritime safety (Oltedal, 2018) and sets a minimum standard for construction, life-saving appliances, fire prevention and firefighting appliances (Fukuoka, 2019). The convention also covers some operational requirements onboard vessels including mandatory drills, familiarization, and onboard training (Dragomir & Utureanu, 2016) that must be carried out by all crew onboard.

Another applicable Regulation is the *International Convention on Standards of Training, Certification and Watchkeeping for Seafarers* (STCW Convention), which stipulates the minimum training requirements for onboard personnel (IMO, 2020). The crew onboard is, according to the STCW Convention, also required to have certified training in safety precautions that is carried out ashore (Szcześniak, 2013). The STCW Convention led also to the creation of the associated *Seafarers Training, Certification and Watchkeeping Code* (STCW Code), which was adopted in 1995. However, considering that the relevant certified training under the STCW Convention and Code is carried out ashore (Dragomir & Utureanu, 2016), it is important to also recognize the importance of onboard training and drills for the emergency preparedness of the crew.

Lastly, the *International Management Code for the Safe Operation of Ships and for Pollution Prevention or International Safety Management Code* (ISM Code) is applicable. The ISM Code was adopted by the IMO in 1993 and became mandatory in 1998 (Parson & Allen, 2018) as a reaction to accidents such as Herald of Free Enterprise and Scandinavian Star (Fukuoka, 2019). The primary aim of the code was to provide a framework to change the safety culture in shipping (Kongsvik, Størkersen & Antonsen, 2014). The ISM Code is also based on ISO 9000 (Batalden & Oltedal, 2018) and enforces ship managers to develop and implement a Safety Management System (SMS) (Parsons & Allen, 2018) onboard their vessels. The ISM Code provides guidance on emergency preparedness and requires that emergency preparedness and response procedures are a part of the vessels' SMS (Batalden & Oltedal, 2018). Its objective is to prevent human injury or loss of life and avoid damage to the environment and to provide for safe practices and a safe working environment.

As mentioned above, emergency preparedness is essential for the safety of the crew onboard. Tac, Akyuz and Celik (2020) argue that insufficient training will lead to a longer response time in the event of an emergency, leading to more extensive damages of the vessel and injuries for the crew. Therefore, the *drills* carried out as part of the emergency preparedness, should reflect realistic (Dragomir & Utureanu, 2016) situations, as this is the best way to educate and prepare crew for an emergency. Realistic drills and training provide the crew with the opportunity to see and utilize the equipment that will be used in an actual emergency (Tac, Akyuz & Celik, 2020) and to practice decision-making and response under stressful (Dragomir & Utureanu, 2016) and realistic conditions. Despite the importance and cruciality of emergency preparedness and the fact that it is regulated in several international codes and conventions, Tac, Akyuz and Celik (2020) argue that drills are often not carried out or are postponed. It can be stated further that drills onboard can also be carried out insufficiently, with the only purpose to fulfil the legal requirement of conducting a drill (Szcześniak, 2013). However, this type of drills does not provide the important training and sufficient preparation (Szcześniak, 2013) for an emergency onboard. The failure of performing sufficient and realistic drills may be due to the workload of the crew (Tac, Akyuz & Celik, 2020) or the lack of a safety culture onboard (Szcześniak, 2013).

In relation to the regulatory framework, the ISM Code (ISM Code, Section 8, 2018) requires shipping companies to establish procedures for how to respond to emergency situations. During drills, these procedures' effectiveness shall be tested and evaluated (International Chamber of Shipping [ICS], 2019). In the same context, SOLAS (SOLAS, 1974) identifies a number of drills that must be carried out on a regular basis, one of them being *fire drills*. Szcześniak (2013) argues that firefighting drills are, together with abandon ship drills, the most important drills onboard. Fire drills aim to ensure that the crew's competency and skills in firefighting are maintained and that there is a readiness to respond to a fire onboard (Wu, Jin & Fu, 2014). However, fires and explosions are one of the most common (Baalisampang, et. al., 2018) maritime accidents and it has been evident that accidents involving fire or explosion are more than twice as mortal (Weng & Yang, 2015). Furthermore, fatalities in fire accidents are reportedly higher (Baalisampang, et. al., 2018) than in other types of accidents, as fires provide little time for response and evacuation. However, according to Paris MoU (2020), fire drills are in the top three deficiencies within the category 'emergency systems' for inspections carried out over the last three years.

In addition to the above, Baştuğ, Asyali and Battal (2020) argue that the implementation of the ISM Code onboard and ashore may often be inadequate due to factors such as lack of motivation for safety culture and conflicting perceptions between shore management and shipboard personnel. The poor implementation of the ISM Code and other issues, like the lack of involvement of shipboard personnel in developing the relevant procedures, may result in breaches (Baştuğ, Asyali & Battal, 2020) to the procedures. However, the crew's emergency preparedness and ability to act correctly and promptly in relation to fire is indeed essential for the outcome of the event. Therefore, and based on the above statements, it can be suggested that there is a need to investigate what skills the crew must obtain through fire safety training and what factors have an impact on fire safety training onboard. These aspects are investigated in this thesis in conjunction with the statutory requirements according to SOLAS, the STCW Convention, the STCW Code and the ISM Code and from data collected through interviews.

1.2 Objective and Research Questions

The objective of this thesis paper is to identify and analyse what skills concerning fire safety training are considered important and what factors have an impact on fire safety training onboard. Theories in relation to Skills and Safety Culture are reviewed in order to obtain a basic foundation of the relevant concepts. The Grounded Theory, as presented by Charmaz (2006) is used for analysing the data obtained through this research. This investigation is done in conjunction with the relevant requirements under the applicable Regulations, such as the SOLAS Convention, the STCW Convention and associated STCW Code and the ISM Code and by comparing qualitative data obtained through interviews with shipping professionals.

Research questions

- What skills concerning fire safety training are considered important?
- What factors have an impact on fire safety training onboard?

1.3 Research Design

The research for this thesis commenced with a literature review of the applicable Rules, Regulations and articles relevant to safety and safety training onboard, which was subsequently narrowed down to specific provisions and information relevant to fire safety and fire safety training. Based on the knowledge acquired through the literature review, interview questions were formulated in order to interview onboard and shore personnel with experience in (fire) safety and (fire) safety training. The interviews were conducted online and recorded in order to transcribe the collected data and compare and analyse it with the information acquired during the initial literature review. This analysis was then considered in conjunction with the objective of this thesis, as well as in relation to relevant theories to formulate concrete conclusions and findings relevant to the research questions.

1.4 Delimitations

The thesis is subject to various limitations in terms of time, resources and scope. In terms of *time and resources*, the thesis project was performed within a five-month time frame by two Master students. Due to the ongoing Covid-19 pandemic and the relevant recommendations for social distancing and remote work, the thesis was conducted remotely, with online meetings, interviews, supervisions and presentations. Microsoft Teams, Zoom and Google applications such as Google Drive, were used as tools and online resources for communication and collaboration throughout the research.

In terms of *scope*, the thesis focuses on investigating fire safety and fire safety training onboard vessels from a compliance and practical perspective, as well as investigating the impact of different factors, such as the safety culture onboard, on the training. In relation to investigated aspects of fire safety training, the research focuses primarily on the skills that crew should obtain through their training and on what factors have an effect on the fire safety training and fire drills onboard. In terms of the review of applicable Regulations, this was limited to the review of three main regulations, being the SOLAS Convention, the ISM Code and the STCW Convention. The STCW Code was also considered in conjunction with the STCW Convention. In terms of theories used for analysing the data, the Grounded theory as presented by Charmaz (2006) was used and in terms of theories for interpreting the data, theories in relation to Non-Technical Skills by Fjeld et. al. (2018) and Safety Culture by Mylett (2010) and Blair (2013) were considered.

In relation to the chosen qualitative data collection method, the researchers chose a combination of literature review and conducting interviews. The *interviewees* approached were limited to 15 individuals with working experience from Swedish shipping companies. From the 15 individuals that were approached for an interview, 12 reverted with a positive reply and interviews were conducted. Swedish shipping companies are in this study defined as Swedish owned and/or registered companies or companies with Swedish management, regardless of whether their vessels are flying a Swedish flag or not. Therefore, any regulations or

requirements relating to the flag of the vessels, where the interviewees are working or have worked, have not been considered in this thesis. Limitations exist also in relation to the capacity and/or rank of the interviewees, as these are primarily officers (both in deck and engine departments) working or having worked onboard. Furthermore, shore personnel with work descriptions relevant to safety and/or safety training, such as safety superintendents, safety controllers and DPAs, were also chosen for the interviews. The majority of the interviewees had experience from the tanker sector, while the minority of the interviewees had experience from the Ro-Ro/Ro-Pax sector. In addition to the above, the majority of the interviewees was of Swedish nationality. Finally, there are also limitations in terms of the selected type of vessels that this research focuses on, being oil and chemical tankers and Ro-Ro/Ro-Pax and/or passenger vessels.

2. Theories

2.1 Safety Culture

For analysing the data on this thesis paper that relate to the factors that have an impact on fire safety and fire safety training, the researchers consider the general phenomenon of Safety Culture. This is done in order to better understand the impact of the human factor and of the general culture onboard in relation to fire safety and fire safety training onboard. In understanding the general phenomenon and concept of safety culture, some definitions and key elements have been presented by different researchers such as Mylett (2010), where in his work 'Safety culture: conceptual considerations and research method' refers to it as 'concrete practice' and focuses on working practices, behaviors, and on what individuals working within an organization think and what they value. In addition, Hopkins (2002) mentions in his work on 'Safety Culture, mindfulness and safe behavior, converging ideas', different aspects that may be interrelated to Safety Culture, such as 'mindfulness' and 'safe behavior' and refers to aspects such as 'safety climate', 'culture of safety' and 'mindsets' of people working within an organization. When it comes to the above definitions, these may be particularly relevant when it comes to fire safety and fire safety training, as the development and implementation of routines and practices onboard may be very dependent on the 'atmosphere' onboard, the 'safety climate' onboard and on what seafarers think and how they act in relation to safety and safety training.

Furthermore, and according to Blair (2013) in order to create a strong safety culture, companies, such as shipping organizations should first of all, 'work and strive toward being a 100 percent reporting culture', secondly, 'develop safety awareness with meaningful safety rules' and thirdly, 'ensure that leaders understand how to consistently act to develop a safety culture'. All these three elements appear to have a particular importance and relevance when it comes to safety culture within a shipping company, as the reporting of non-conformities, fire hazards and incidents involving fire is stipulated within the relevant Regulations, such as SOLAS and the ISM Code and may be essential for elevating the fire safety training onboard. In addition, shipping companies should create and implement procedures and rules in relation to fire safety and fire safety training that increase the risk and safety awareness and safety culture onboard, as stipulated also within Regulations, such as the ISM Code. Finally, the impact of leadership behavior is also great when it comes to developing a safety culture onboard, especially in relation to the Master and the officers onboard who give the general guidance and direction and 'lead by example' when it comes to safety and training.

Based on the above, it can be suggested that safety culture can be viewed from many different perspectives and may entail many different concepts, even though a clear definition may not be easy to obtain or fully understand. However, the common denominator appears to be that safety culture is dependent on people's behaviours, group dynamics, and collective understanding of what are the common objectives, structures and priorities within the group and within an organization. Based on these assumptions, one may presume that the importance of safety culture is great when it comes to fire safety and fire safety training, in relation to what

individuals onboard and ashore prioritize, how they act and follow procedures and requirements. That said, considering the importance and the impact of safety culture onboard on the outcome of fire safety training, its components are to be considered and researched within this thesis paper and compared with the results of the primary and secondary data collection.

2.2 Skills

For analysing the data referring to the social skills that are important for the crew to obtain through fire safety training, the research on Non-Technical Skills (NTS) by Fjeld et.al (2018) was reviewed. The study focused on identifying and understanding the interpersonal and cognitive skills that ship's bridge officers should obtain in relation to navigation. The study identified five categories of Non-Technical Skills, being *Communication, Leadership, Work-load Management, Decision-Making and Situation Awareness*. The Non-Technical skills described within this study are considered to be complementary to technical skills and contributing to the successful undertaking of different tasks onboard. Therefore, the Non-Technical skills mentioned above should not be considered as being separate or conflicting to the technical skills, but rather supportive and interrelated.

Fjeld et al. (2018) state further that in the shipping sector, there is also a clear link between the lack of Non-Technical skills and the increased risk of accidents. In support of that, the authors refer to the study by Hayward and Lowe (2010) claiming that up to 75 to 80 percent of maritime accidents might be caused due to human error. Fjeld et al. (2018) refer further to the development of Bridge Resource Management (BRM), which can be trained in maritime training centres and which focuses on some of the NTS, such as communication, collaboration, stress management and decision-making. They further support the importance of these skills by referring to relevant applicable legislation such as the STCW Convention, which stipulates that bridge officers should demonstrate competence in relation to leadership and managerial skills.

According to Fjeld et al. (2018), *situational awareness* refers mainly to how the environment is perceived, how relevant information is understood and interpreted and how this information is projected to the future. Some typical errors in relation to this skill that are identified by Nishizaki and Takemoto (2015) are the 'delay of attention' and the 'discontinuation of attention' and others may relate to failure in communication. The second NTS, being *workload management*, is considered by Fjeld et al. (2018) to be relevant to the requirements under the STCW Convention, where skills such as managing tasks and workload are mentioned. They further refer to previous research focusing on two strategies that are used by the bridge officers, being 'adaptation' and 'anticipation of the workload based on prior knowledge'. This skill appears to require prioritization between tasks and problem solving, while remaining calm during a stressful situation.

Another NTS reviewed by Fjeld et al. (2018) is *decision-making*, which is presented by the

authors as consisting of four steps, being ‘situation and risk assessment, identification of the different available options, decision on the most suitable course of action and evaluation of the outcome and its effectiveness’. According to the authors, a more experienced individual would make decisions more intuitively based on an analytical assessment of available strategies compliant with the relevant applicable procedures. Furthermore, Fjeld et al (2018) refer to *leadership* as an essential NTS, which includes skills in planning, prioritizing, setting standards and managing workload by using authority. Finally, the authors refer to *communication*, as being an important ‘multifaceted tool’ for providing information, ‘clarifying role distribution’ and issuing orders.

3. Methodology

To answer the research questions in this thesis, a thorough *literature review* was performed, as well as a review of the applicable Rules, Codes and Regulations and Theories relating to fire safety and training onboard. Furthermore, *interviews* were carried out with individuals with seagoing experience in order to collect primary information for the "actual situation" onboard and how fire safety training works in practice. Interviews were also carried out with individuals working within the shore management of Swedish shipping companies, in order to identify how the Rules, Codes and Regulations are implemented in their procedures. The overall aim was to carry out approximately 12 to 15 in-depth interviews in total, which were to be conducted online, recorded and transcribed. Thereafter, a comparative analysis of the data collected from the interviews was made also in conjunction with the Rules, Regulations and the practices onboard against Theories relating to Skills and Safety Culture.

3.1 Background Research

The initial background research included a literature review of the applicable Codes, Rules and Regulations in relation to maritime safety and crew training. These are primarily the SOLAS Convention, the STCW Convention and STCW Code and the ISM Code. The review of the applicable regulations provided a solid foundation of knowledge required to understand the legal regime behind safety training on board and the legal requirements that need to be fulfilled. In terms of articles, the initial selection of articles for the background of this study was made with the use of the keywords; safety training, safety management, maritime training, SOLAS, STCW, ISM Code, fire safety, firefighting, fire prevention, or combinations of such keywords. Relevant articles were located within Research Gate, Scopus and using the search engine of the Chalmers Library. The Boolean operator AND was also used to connect the keywords in order to search within the database.

A second literature search was conducted for the literature review. It was foremost carried out using the search engine Scopus. Since this research is focused on onboard safety training related to fire, this was included in the keywords used. The keywords; fire; safety training; safety management; SOLAS; ISM Code; emergency preparedness; maritime and shipping were used when searching in Scopus. The first search done was using the keywords maritime OR ship AND drill OR safety training OR emergency preparedness AND management to find articles with these keywords. This search resulted in 75 documents, whereof 11 were selected for further review based on the content of the abstract. These 11 articles were read to identify their relevance for this research. Based on the articles that were relevant, further articles were found based on citations of and references in those articles. This resulted in a total of 13 articles included in the review of previous research.

3.2 Qualitative Data Collection

In-depth semi-structured interviews were used as qualitative data sources for this thesis, in order to acquire information on the practices onboard vessels in relation to fire safety and fire safety training. The interview method was adopted for data collection first of all because

interviews are considered to be something that individuals feel comfortable with (Schostak, 2006), as they involve a face-to-face active interaction between the interviewer and the interviewee. According to Schostak, the interview as a qualitative data collection method, provides in-depth information and is a method that enables dialogue and promotes change and development. It further involves personal interpretations of the interviewer and the interviewee, which give light to different perspectives and angles of the topic in question. On the other hand, due to the personal and often subjective view of the parties involved, the interview as a method can also include some *drawbacks*, such as the risk of misunderstandings (Schostak, 2006), misinterpretations and possibly also bias. Therefore, this aspect is considered by the researchers throughout this study.

However, it can be suggested that the *benefits* acquired from the interview as a qualitative data collection method outweigh the disadvantages. That is because conducting interviews provide the researchers with in-depth information, personal experiences and feelings, which are not easily obtained with the use of quantitative methods of data collection. In addition, a further advantage of interviews is that they *'facilitate rapport and empathy to gain rich and interesting data'* (Smith J.A., et al., 2009). That can be achieved by performing one-on-one interviews, enabling the researchers to focus on the interviewee, ask tailor-made follow up questions and observe facial gestures. For enabling the researchers to obtain large amounts of data from interviews conducted, the interviews can be audio-recorded and then transcribed in order to be able to capture the interviewees words and expressed feelings (Smith J.A., et al., 2009).

Other methods for obtaining primary data, such as questionnaires, were initially considered by the researchers, however they were found not suitable for the subject thesis. That is because the nature of the research questions in this thesis requires obtaining personal views and interpretations that are difficult to capture by using standardised yes/no answers in questionnaires. Furthermore, utilizing questionnaires would require a much larger sample of individuals with working experience from the shipping industry, which might not have been available in the relevant time frame. Therefore, the use of interviews as a method for obtaining primary qualitative data was considered to be the most suitable considering the objectives and limitations of the subject thesis.

For this thesis, 15 interviewees with working experience from Swedish shipping companies, having worked either onboard as officers or ashore within the management of a shipping company with experience relevant to safety training, were chosen and contacted for an interview. The interviewees were found through the researchers' personnel network and contacts within the shipping industry. It is believed that a sample of 12 to 15 interviews for this thesis provides sufficient data for the purpose of formulating answers to the research questions in this thesis paper, due to the rich and large amount of data deriving from the in-depth interviews. That is further supported by the duration of the interviews, which varies from 40 minutes to one hour each, thus generating a large amount of data. From the 15 individuals that were approached, 12 interviewees responded positively, and interviews were conducted with

them, whereas three individuals did not respond and/or responded negatively. In the below table, the distribution of the interviewees, with whom interviews were conducted, can be observed according to rank, segment, employment and years of working experience in total.

	Rank	Segment	Employment	Years
1.	2nd Engineer	Ro-Pax	Onboard	5
2.	2nd Officer	Tanker	Onboard	2,5
3.	Master	Tanker	Ashore	30
4.	Master	Tanker	Onboard	> 15
5.	DPA	Tanker	Shore management	25
6.	Master	Tanker	Onboard	> 10
7.	Chief Officer	Tanker	Onboard	6
8.	Safety Controller	Ro-Pax, Ro-Ro	Shore management	15
9.	Master	Tanker	Onboard	> 15
10.	HSE Superintendent	Tanker	Shore management	20
11.	Safety and Security Superintendent	Ro-Pax, Ro-Ro	Shore management	15
12.	2nd Engineer	Tanker	Onboard	6

Table 1. *Matrix of Interviewees*

The *distribution* of the interviewees were four interviewees currently working within the shore management of shipping companies, two within the tanker segment and two with the Ro-Pax/Ro-Ro segment. Seven of the interviewees were currently working onboard ships, whereof six onboard tankers, as officers either within the engine or deck department onboard. One interviewee had previously worked onboard tankers but was at the time of the interview working within the maritime industry ashore. The interviewees' experience of working within the maritime industry varied from 2,5 years to 30 years and the average years of experience of the interviewees is 13 years. Even though the current employment was mostly taken into consideration when categorizing the interviewees in different segments, it can be stated that some of the interviewees had previous experience from different sectors as well. Some interviewees from the tanker segment had also experience from the Ro-Pax/Ro-Ro segment and vice versa. However, the majority of the interviewees were, at the time of the interview, employed within the tanker segment.

Finally, as in typical semi-structured interviews, the *interview questions* were planned, and all interviewees were asked the same core questions in the same order but leaving room for individual follow up questions. The majority of the questions were, however, open-ended, without a fixed choice of answers. One in-depth semi-structured interview was performed with each interviewee online, which was recorded and then transcribed in order for the data to be analysed for this thesis. The recorded material resulted in 98 pages of transcribed data, which was used in order to analyse the relationship between the applicable rules, regulations and practices regarding safety training onboard and to answer the research questions.

3.3 Transcription Technique

The transcription technique was used in this thesis paper in order to acquire a written report of the recorded interviews. Transcription is a practice that is considered to be very important in qualitative research (Davidson, C., 2009) and the transcripts are viewed as *'the result of a series of choices in need of explanation'* (Ochs, 1979). That is because transcription is viewed by some researchers as *'a selective process reflecting theoretical goals and definition'* (Ochs, 1979) and this, according to Davidson, remains unrefuted. Furthermore, transcription is considered by other researchers to be a representational process (Green, et. al, 1997) that encompasses 'what is represented in the transcript (e.g., talk, time, nonverbal actions, speaker/hearer relationships, physical orientation, multiple languages, translations); who is representing whom, in what ways, for what purpose, and with what outcome; and how the analysts position themselves and their participants in their representations of form, content, and action' (Green et al., 1997).

Furthermore, according to Davidson, transcription *'entails a translation'* (Slembrouck, 2007; ten Have, 2007) or *'transformation of sound/image from recordings to text'* (Duranti, 2007) as it requires some personal interpretation by the analysts. Davidson considers this a selective process, as only '*specific features of talk and interaction are transcribed'* (Davidsson, 2009), considering that the analysts make selections or interpretations consciously or subconsciously during the entire transcription process. However, this should not be perceived as problematic, but rather necessary (Cook, 1990; Duranti, 1997), as it is impossible and would be inefficient to try and transcribe all features.

Furthermore, according to Davidson, the invention of audio recording devices has enabled researchers to review language data several times in order to *'produce transcripts of naturally produced language'* (Sacks, 1995) based also on interpretations and selections by the analysts. Therefore, computer recordings using Microsoft Teams were used on this research in order to record and then transcribe the interviews conducted. Finally, due to the time-consuming nature of verbatim transcription and the limited timeframe for conducting this thesis paper, the researchers decided to use a combination of *verbatim* and *non-verbatim* transcription technique depending on the relevance of the answers to the research questions. Therefore, answers that were considered imperative and/or relevant to the research objectives were transcribed word-by-word, while answers that were not directly relevant to the research questions may have been

transcribed non-verbatim. That said, the non-verbatim technique focuses more on the core message, rather than word-by-word transcription, and removes e.g., filler words in order to keep the actual meaning of what the speaker said. It is therefore believed that this thesis paper benefited more from a combination of both techniques due to the large amount of data generated from the in-depth interviews and the existence of both relevant and non-relevant information that were obtained via this data collection method.

3.4 Analysis Method

The *Grounded Theory*, being 'an inductive and comparative methodology that provides systematic guidelines for gathering, synthesizing, analysing and conceptualizing qualitative data' (Charmaz, 2006), was used when conducting this thesis project. According to Charmaz, grounded theorists begin initially with data collection through different methods, such as observation, interactions and materials gathered in relation to the topic in question (Charmaz, 2006). Therefore, it is important when using the Grounded Theory to gather at the very initial stages as much as possible rich data and to identify the method for doing so. Charmaz argues that the researchers should let their research problem shape the methods they choose for their study. Due to the purpose of analysing the relationship between Regulations and Practices regarding fire safety training and fire drills onboard, the material gathered for this thesis project was collected initially from articles, research, and Regulations and then from intensive interviews conducted with different shipping professionals. Based on Charmaz, intensive qualitative interviewing fits well with grounded theory methods due to the *'combination of flexibility and control'* that they entail (Charmaz, 2006). Therefore, the method of interviewing was considered the most appropriate for this thesis project in order to gather first-hand information about fire safety training and practices onboard.

When the initial data collection has commenced, grounded theorists try to separate and sort the data through *coding*, into different segments or categories, in order to be analysed and/or compared (Charmaz, 2006). The theory suggests that the researchers start with a broader or many broader concepts, which later on can be summarized or narrowed down into more specific concepts or codes. These codes can be represented in the form of e.g., keywords or short explanatory sentences, in order to define what the data actually means and to identify patterns. Some researchers perform coding from notes, while others prefer to perform coding from transcribed interviews. In this research, coding was performed in the form of keywords and key phrases from full interview transcriptions in order to avoid the risk of missing important information or concepts not included in the notes.

Thereafter, the information collected was summarized, analysed, or compared further by creating preliminary *analytic notes or memos* (Charmaz, 2006). The memo-writing process is considered crucial by Charmaz, as it constitutes an 'intermediate step between data collection and writing drafts of papers' and enables the researcher to make useful comparisons between data, codes, categories and concepts. For example, a type of comparison in memos mentioned by Charmaz is the comparison of statements or incidents within the same interview or the

comparison of statements or incidents between different interviews. One can also compare different individuals, different actions and different experiences. In this thesis paper, several indirect or direct comparisons were made within such memos, such as comparisons between different shipping sectors, here being the tanker sector and the Ro-Ro/Ro-Pax sector, between onshore and onboard personnel, between different ranks (crew -versus- officers onboard) and between Rules, Regulations, Theories and practices onboard. Finally, using the Grounded Theory within this research entailed some advantages and disadvantages. Using the Grounded Theory enabled the researchers to start by gathering a rich amount of data that were relatively structured and then proceed to restructure the data in order to identify new emerging themes, patterns and ideas. That enabled the researchers to focus on new interesting themes within this data and adjust the research questions accordingly. On the other hand, the use of the Grounded Theory was complex and required a very good understanding and overview of all the data obtained and the ability to identify key areas within a large amount of data.

3.5 Ethics

When conducting this thesis, ethics have been considered in relation to the research itself and the researchers' personal conduct. That is because the nature of research is subject to different interests, such as the interest in knowledge and the interest in the integrity of the research subject and these interests can often give rise to conflicts and moral dilemmas. According to the European Federation of Academies of Science and Humanities' (ALLEA) Publication '*The European Code of Conduct for Research Integrity*', when conducting research, one should consider the four principles of reliability, honesty, respect and accountability (ALLEA, 2017). These refer to the quality of the research, its transparency, the attitude of the researchers towards all involved parties and finally, its credibility.

That said, ethics were considered in this thesis when conducting the research, when performing the interviews and when treating data and personal information obtained. Attention and care were given to the treatment of the interviewees' personal information in order to provide also a satisfactory level of *anonymity* throughout this research. This was achieved by not stating any individual names or company names within this thesis paper, but only referring to sectors and professional titles or ranks. Furthermore, the interviewees were informed before the interview about how their data will be treated and they were asked to provide *verbal consent* agreeing to the recording of their interviews and the use of their content for this thesis. A written consent document was created by the researchers, which was shown to each interviewee before the interview commenced, and can be found in Appendix I. As the online interviews were recorded, the interviewees were also informed that these recordings are treated as *confidential*. Finally, special care was given to the formation of the interview questions in order to ensure, as much as possible, a high level of objectivity and neutrality. The interviewees were also encouraged to provide honest opinions and personal interpretations without being criticized by the interviewers.

4. Rules and Regulations

4.1 SOLAS

The SOLAS Convention, being the International Convention for the Safety of Life at Sea, was signed in 1914, adopted in 1974 and entered into force in 1980. The creation of the SOLAS convention is considered to be a response to the Titanic accident in 1912 and it is believed to be the most important international convention in relation to the safety of merchant vessels (IMO SOLAS, 2019). The purpose of the SOLAS Convention is to regulate and introduce, first of all, minimum safety standards for ship construction and operation, the compliance to which can be verified by external parties, such as flag states and port state control. The compliance to the requirements of the SOLAS Convention can be done more specifically in the form of surveys, audits, or inspections and with the renewal and provision of relevant Certificates (SOLAS Chapter I, 1974). In relation to ship construction, the SOLAS convention sets minimum standards, such as the provisions for passenger vessels to have watertight compartments to ensure that the vessel will remain afloat after a major casualty (IMO SOLAS, 2019).

Other aspects covered within the SOLAS Convention are *fire protection and detection and firefighting appliances*. The relevant provisions within Chapter II, include principles, such as the efforts to contain and extinguish a fire at an initial stage at the very source and the access to firefighting equipment and appliances (IMO SOLAS, 2019). Furthermore, Chapter III of the SOLAS refers to *life-saving appliances*, such as lifeboats and jackets, and Chapter IV to radiocommunications in order to establish, for example, the exact position of the vessel after an accident. Chapter V refers to the safety of navigation, including ice patrol services and routeing of vessels (IMO SOLAS, 2019) and other provisions, such as the obligation for the existence of VDRs (Voyage Data Recorders) and AIS (Automatic Identification System) onboard all vessels. The data from VDR and AIS are usually retrieved and reviewed after incidents like major fires, collisions and groundings, in order to establish the cause of the accident and the sequence of events. In addition to the above, Chapter VII of the SOLAS Convention includes provisions relating to the Carriage of *Dangerous Goods*, such as requirements for packing, labelling and documenting and refers to the mandatory application of the IMDG Code (International Maritime Dangerous Goods Code) (IMO SOLAS, 2019). These provisions can be relevant also in relation to fire safety due to the existence and carriage of explosive and/or toxic cargoes that may require special treatment to prevent accidents e.g., due to overheating. Furthermore, under Chapter IX, there are provisions for the mandatory application of the ISM Code (International Safety Management Code), which is presented in detail later on in this report.

The SOLAS Convention also provides for operational aspects onboard vessels, such as *mandatory drills* and *onboard training and familiarization* (IMO SOLAS, 2019). These drills should be carried out regularly in order for the crew to practice their actions and reactions in case of emergencies such as fire, collision and capsizing. That said, in the fourth version of the SOLAS Convention, adopted in 1960, the issue of maritime training in relation to safety of

navigation was considered. The training of the crew should cover, among others, the use of navigation tools, the use of firefighting and lifesaving appliances and training for using modern technology (IMO SOLAS, 2019). Further to this, in the version adopted in 1974, the SOLAS Convention provided for *'specific mandatory drills'* by the crew in order to advance the safety and security onboard the vessel (IMO SOLAS, 2019). These drills cover, among others, drills for the operation of watertight doors, fire drills, abandon-ship drills, enclosed space entry or rescue drills and emergency steering drills. The relevant provisions include guidelines for the regularity of the drills (weekly, monthly, bi-monthly etc.) and whether or not the entire crew should participate in the drill. In more detail, drills for operating watertight doors in passenger ships should take place weekly and fire drills and fire training onboard should include using the vessel's fire extinguishing equipment. In relation to abandon-ship drills and fire drills, every crew member should participate in at least one drill per month, however, in passenger vessels these drills are to be done weekly. In relation to enclosed space entry and entry drill, crew should participate at least once every two months (IMO SOLAS, 2019). Finally, emergency steering drills are to take place at least once every three months and may include, among others, operation of alternative power supplies (IMO SOLAS, 2019). In practice, some of the drills mentioned above can also be combined to achieve maximum efficiency and more realistic scenarios that may include e.g., a fire drill, a medical emergency and an abandon-ship drill.

Chapter II-2 of SOLAS, referring to Construction-Fire Protection, Fire Detection and Fire Extinction, includes general provisions and specific provisions relevant to passenger ships, cargo ships and tankers. (SOLAS, 1974). The general provisions include *basic principles* such as (SOLAS, 1974)

- the detection of any fire in the zone of origin
- the containment and extinction of any fire in the space of origin
- the access to firefighting and ready availability of fire extinguishing appliances and
- the minimization of possibility of ignition of flammable cargo vapour.

In relation to the above, particular emphasis should be given to the detection, containment and extinction of a fire at the source, the availability of fire extinguishing appliances and access to firefighting equipment, which may be trained also during a fire drill onboard. The crew and officers onboard should therefore have basic theoretical and practical knowledge about different types of fire (electrical, chemical etc.) and ways to contain or extinguish them at an early stage. They should also be able to handle the relevant equipment and firefighting appliances in an effective way and test the availability and good working order of fire extinguishing appliances during the fire drills conducted onboard.

Furthermore, under Chapter II, Regulation 4, every ship is required to be equipped with *fire pumps, fire mains, hydrants and hoses.* The fire pumps are expected to have a required capacity and to be able to deliver a specific quantity of water at a specified pressure for firefighting purposes. Specific provisions in relation to the number of fire pumps and fire mains are also included, depending on the type and size of vessel. Further provisions relate to e.g., the

diameter and pressure in the fire mains, the number and position of hydrants and the number and length of fire hoses. Regulation 5 refers to Fixed Gas Fire Extinguishing systems, to Carbon dioxide systems, to halogenated hydrocarbon systems and steam systems, while Regulation 6 and 7 refer to fire extinguishers and fire extinguishing arrangements in machinery spaces. The regulations following, refer to different fire extinguishing systems, such as low-expansion and high-expansion foam and water-spraying, automatic sprinklers and fire detection (fire detectors, smoke detectors and heat detectors) and fire alarm systems. Another important aspect covered under SOLAS Chapter II, is that within Regulation 17 referring to the fireman's outfit, which shall consist of *Personal Protective Equipment* (PPE) comprising of; (SOLAS, 1974)

- protective clothing made from material that can protect the skin from the heat and from burns
- boots and gloves made from electrically non-conducting material
- a helmet
- an electric safety lamp and
- breathing apparatus such as a smoke helmet or smoke mask

It can be suggested that the correct use of the PPE should be part of the training of the crew onboard, which can be practised during a fire drill, and that training in wearing said outfit should be timed in order to simulate a real-life situation. Especially important should be considered the testing of the breathing apparatus during a fire drill, in order to ensure that the equipment is working properly.

In addition to the above, under Chapter II Regulation 20, there are provisions relating to *fire control plans*. These plans, which are applicable for all ships, are to guide the ship's officers in relation to; control stations, fire sections, fire detection and fire alarm systems, sprinkler installations, fire extinguishing appliances, ventilation systems etc. These plans can also be in the form of a booklet, a copy of which should be provided to every ship officer and at least one copy should be available onboard at an accessible location. These plans and booklets need to be regularly updated and written in the official language of the flag state. If the language is neither English nor French, a translation to one of those languages and/or in the working language of the vessel should be included as well according to SOLAS (SOLAS, 1974).

SOLAS Chapter II, Part B, Regulation 23 and onwards, include provisions specifically relating to fire safety measures for *Passenger ships* and referring, among others, to their structure, to the subdivision into main vertical zones and horizontal zones and to the fire integrity of bulkheads and decks, depending on the capacity of the vessels in terms of passengers (SOLAS, 1974). There is also an assessment of risk of fire (low risk or high risk), depending on the area in question (corridors, stairways, accommodation spaces etc.) and provisions referring to means of escape and escape routes. Other relevant provisions refer to e.g., ventilation systems, fixed fire detection and fire alarm systems and automatic sprinklers, fire detection and fire alarm systems. The regulation also includes provisions regarding efficient *fire patrols* and the requirement for a continuous fire watch in special category spaces. It is further required under

Regulation 40 (6), that for ships carrying more than 36 passengers, each member of the fire patrol should be trained in order to be 'familiar with the arrangements of the ship, as well as the location and operation of any equipment he may be called upon to use' (SOLAS, 1974). The members of the fire patrol are also required to have a two-way portable radiotelephone apparatus (SOLAS, 1974). On the other hand, SOLAS Chapter II, Part D, Regulation 55 and onwards, include provisions relating to fire safety measures for tankers. These include provisions relating, among others, to the location and separation of spaces, the fire integrity of bulkheads and decks and to the venting, purging, gas-freeing and ventilation (SOLAS, 1974).

In addition to the above, Chapter III of SOLAS, referring to *Life-Saving Appliances and Arrangements,* includes provisions that may be also relevant in terms of fire safety. Under SOLAS Chapter III, Regulation 19, includes provisions relating to emergency training and drills (SOLAS, 1974). In more detail, Regulation 19 refers to all vessels and states that every crewmember that is assigned emergency duties should be familiar with said duties before the commencement of the sea voyage. Under Regulation 19 Article 3, there are provisions referring to Drills. These drills should ideally be performed in conditions that simulate an actual emergency and every crew member should participate in at least one fire drill every month. These drills are to take place within 24 hours of the vessel departing from port in case more than ¼ of the crew have not participated in fire drills onboard that specific ship in the month before. Furthermore, under Regulation 19 Article 4, there are specific provisions referring to fire drills. Article 19.4.1 states that fire drills should be planned so that 'due consideration is given to regular practice in the various emergencies that may occur depending on the type of ships and the cargo'. In addition, under Article 19, 3.4.2, there is reference to what each *fire drill* should include (SOLAS, 1974).

- reporting to stations and preparing for the relevant tasks as stated in the muster list
- starting a fire pump and using at least two jets of water
- checking of the fireman's outfit and other personal rescue equipment
- checking of communication equipment
- checking the operation of watertight doors, fire doors, fire dampers and main inlets and outlets of ventilation systems in the drill area
- checking the necessary arrangements for subsequent abandoning of the ship

Ideally, the above points should be included in the form of a checklist, which will be used during a fire drill, so that the crew and officers participating in the drill become familiar with the items that need to be covered during the drill under the SOLAS Convention.

Further to the provisions relating to fire drills, under Chapter III, Regulation 19, Article 4 refers to *on-board training and instructions* and that onboard training should include using the ship's fire extinguishing appliances. This practical training should be given to the crew as soon as possible, but not later than two weeks after joining onboard. The article also provides instructions in using and operating the ship's fire extinguishing appliances, which should be provided in the same interval as the drills and ideally all ship's fire extinguishing appliances

should be used within a period of two months. An important aspect covered under Regulation 19 Article 5, is the keeping of *records* of all the relevant musters, drills, such as fire drills, and onboard training in a logbook provided by the Administration. Under Regulation 29, passenger ships are required to have *emergency plans* for emergencies such as fire, damage to ships and pollution and under Regulation 30, they are required to perform fire drills weekly (SOLAS, 1974).

Finally, another important aspect covered within SOLAS, Chapter VII is the Carriage of Dangerous Goods. *Dangerous Goods* are divided to different classes (SOLAS, 1974) being:

- Class 1: Explosives;
- Class 2: Gases: compressed, liquefied, or dissolved under pressure;
- Class 3: Flammable liquids;
- Class 4.1: Flammable solids;
- Class 4.2: Substances liable to spontaneous combustion;
- Class 4.3: Substances which, in contact with water, emit flammable gases;
- Class 5.1: Oxidizing substances;
- Class 5.2: Organic peroxides;
- Class 6.1: Toxic substances;
- Class 6.2: Infectious substances;
- Class 7: Radioactive materials;
- Class 8: Corrosives, and;
- Class 9: Miscellaneous dangerous substances and articles.

It can be observed that several of the above categories can be connected to the risk of fire onboard due to their flammable or explosive nature. Therefore, specific requirements are included in relation to these Dangerous Goods, referring to e.g., packaging, marking, labelling, stowage and documentation (SOLAS, 1974). It can be suggested that the crew and officers involved in cargo operations of Dangerous Goods should be specifically trained and familiar with the requirements for handling of the cargo. Their training should include, among others, information about requirements for handling different classes of DGs, risk awareness and theory behind different types of fires involving Dangerous Goods and practical actions to minimize potential damage and/or injury. Specific provisions can be found also within the International Maritime Dangerous Goods Code (IMDG Code), which is also based on relevant provisions within the SOLAS and the MARPOL Convention (Greencarrier, 2017).

4.2 STCW

4.2.1 STCW Convention

The STCW Convention, which stands for the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, was adopted by the IMO in 1978 and entered into force in 1984. The STCW Convention was the first convention that set minimum requirements on global level in relation to seafarers' training, certification and watchkeeping,

in an effort to unify the relevant rules, which used to vary from country to country (IMO STCW, 2019). The Convention includes chapters referring to; the Master and Deck department, the Engine department, Radiocommunication and the radio personnel, Special Training requirements for Personnel on Certain types of ships, Emergency, occupational safety, medical care and survival functions etc. Parts of the STCW Convention are reflected in the STCW Code, and Part A of the Convention is mandatory, while Part B, is only a recommendation. Substantial amendments to the STCW Convention and Code were done in 2010 and some of the areas covered were hours of work and rest, provisions for the prevention of drug and alcohol, security training, distance learning, training in case of pirate attack and environmental awareness training (IMO STCW, 2019).

Furthermore, other important aspects covered within the STCW Convention, is first of all the requirement for the crew to have a reasonable opportunity to be familiar with the *specific ship* in terms of its equipment and operating procedures. The fulfilment of this requirement is the responsibility of the Owner of the ship and/or the Master and can be done in the form of an introductory programme. Another important aspect covered within the STCW 2010 amendments is the *Certification* requirements. The 2010 version refers to the Certificate of competence, the Certificate of proficiency and other Documentary evidence (IMO STCW, 2019). The Certificate of competence provisions vary depending on the capacity of the seafarer (e.g., Master, Chief Mate, Chief Engineer, OOW, Radio operator etc.), the area limitation (e.g., near coastal or no limitation) and the tonnage limitation or propulsion power limitation (e.g., less than 500gt, less than 3,000gt, 750 kw to 3,000 kw etc.). On the other hand, the Certificate of Proficiency provisions vary for personnel working on different types of vessels (e.g., tankers and passenger ships) and for seafarers who have duties relating to safety, security and pollution prevention (e.g., safety and care of persons or of cargo). Finally, when referring to other Documentary evidence, these may include documents confirming participation in safety drills, basic safety training and familiarization training (IMO STCW, 2019).

4.2.2 STCW Code

In 1995, a Conference of the Parties to the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers was held and convened by the IMO (IMO STCW, 2019). The 1995 STCW Conference decided on relevant amendments to the Convention and subsequently adopted the Seafarer's Training, Certification and Watchkeeping Code (STCW Code). It can be stated however that the Code contains more detailed requirements, which are based on the general provisions of the STCW Convention. In reflection of the STCW Convention, Part A of the STCW Code is mandatory, while Part B contains general recommendations and guidance. In relation to fire safety, relevant provisions can be found in the STCW Code and these provisions refer to techniques and knowledge that is required for firefighting (IMO STCW, 2019).

In relation to fire safety, the ultimate goal of the amendment is to enable the crew to 'create a realistic shipboard fire prevention program, to effectively organize fire teams and to respond

to fires onboard a ship' (EduMaritime, 2021). The candidates for the relevant certification are required to prove that they acquire the standards of competence as stipulated within the Code. Furthermore, seafarers who have acquired the relevant qualification need to provide proof every 5 years showing that they have maintained the said standards of competence. This proof shall be satisfied, if the seafarer has had onboard training and experience in the following areas as stipulated within the STCW Code as amended in 2010, Table A-VI/3 (STCW 2010, Resolution 2) such as:

- participate in firefighting operations onboard
- use of water for fire extinguishing
- communication and coordination during firefighting operations
- ventilation control
- firefighting arising from Dangerous Goods
- management of injured persons and
- coordination with shore-based firefighters or emergency services

It can also include onboard training and experience in organizing and/or training fire parties, including duties and tasks such as the preparation of contingency plans, the allocation of duties and responsibilities and the creation of plans to contain and/or extinguish fires in different areas of the ship. Finally, it may also include training or experience in relation to the inspection of any fire detection and fire extinguishing systems or equipment onboard and the investigation and creation of reports on incidents involving fire onboard. The above can be done through theoretical and practical exercises (also in darkness), in realistic conditions and training environments and by using the relevant equipment. Referring to Part 2 of the STCW convention in relation to 'Mandatory Short Courses and STCW Regulation Endorsement', the relevant requirements provide for basic safety training for all new entrants in fire prevention and firefighting (A-VI/1-1), as well as advanced firefighting courses (A-VI/3) (IMO STCW, 2019).

4.2.3 Manila Amendments to the STCW Convention

Finally, particular emphasis should be given to the *'Manila Amendments'* to the STCW Convention, agreed by governments in Manila in 2010 and entered into force in 2012 (ICS 'Manila Amendments', 2020). The new key requirements under the 'Manila Amendments' refer to changes to competence tables, especially when it comes to *environmental management* and to the requirements for *leadership, teamwork and managerial skills* for deck and engine officers (IMO STCW, 2019). Other amendments refer to the use of onboard training record books, to mandatory security training and to *refresher training*, including firefighting, every five years. Additional medical fitness standards and requirements were also introduced, as well as specific limitations for the prevention of unsafe alcohol use onboard (ICS 'Manila Amendments', 2020).

A number of important changes were adopted also in relation to other aspects, such as the improved measures to prevent fraudulent practices in relation to certification and in relation to

new requirements for training in *modern technology*, such as Electronic Charts and Information Systems (ECDIS) (IMO STCW, 2019). Some of the above amendments are particularly relevant in relation to the subject thesis and in relation to the *skills* that officers should obtain through fire safety training, like leadership and teamwork. However, it can be suggested that skills like teamwork would be important also for the rest of the crew to obtain through fire safety training and fire drills. Equally important appear to be the updated requirements in relation to the *refresher training*, which also includes firefighting, every five years for all crew members.

4.3 ISM Code

The ISM Code, which entered into force in 1998 (Andersson, 2015) is a part of SOLAS and mandatory for all ships with a gross tonnage of 500 and above (Anderson, 2015). The origin of the ISM Code is known to be the capsizing of Herald of Free Enterprise in 1987 (Fukuoka, 2019), where the major causal factor of the accident was the poor shore and safety management (Anderson, 2015). Another reason behind the creation of the ISM Code, was the fact that the cause of many accidents had been identified as *'human error'* (Anderson, 2015). Therefore, the ISM Code aims to improve the *Safety Culture* within the shipping industry, through improving procedures and minimizing human errors (Oltedal & Lützhöft, 2018), in order to prevent injuries or loss of life and avoid damage to property and the environment (ISM Code, p. 16, 2018).

Under the ISM Code, shipping companies are required to develop, implement and maintain a *Safety Management System* (SMS), with the objective to provide safe operation practices and working environment; establish safeguards against assessed risks to the ship, its crew and the environment; and the continuous improvement of all personnel's safety management skills including preparations for emergencies, both onboard and ashore (Oltedal & Lützhöft, 2018). The ISM Code is a regulatory framework, which should support the safety culture (Kongsvik, Størkersen & Antonsen, 2014) within the company and onboard. Furthermore, the ISM Code enforces self-regulation (Batalden & Sydnes, 2014) in the maritime industry, which means that the shipowner shall develop, implement and maintain a SMS where practices and procedures are regulated to laws and regulations (Batalden & Sydnes, 2014).

One important thing to address regarding the ISM Code is the definition of '*the Company*'. The Company is defined as the person or organization "who has assumed the responsibility for operation of the ship ... [and] ... has agreed to take over all duties and responsibility imposed by the Code" (ISM Code Part A, 1.2.2, 2018). The Company that is referred to in the ISM, and in this thesis, is therefore not synonymous to the shipowner. The company may be the shipowner, but also an external ship management company or likewise (Anderson, 2015), which has the responsibility to develop, implement and maintain the SMS and fulfil the requirements of the ISM Code.

Furthermore, the ISM Code does not regulate the type of drills that must be carried out or the frequency in which they need to be carried out, but sets the requirement that the company must establish *procedures* for potential emergency situations. The company must, first of all, identify any potential emergency situations and then create procedures for how to respond to those emergency situations onboard. Secondly, the company shall establish a drill and exercise programme in order to prepare for the identified emergency situations (ISM Code, 2018). However, the ISM Code is very broad and gives no specific requirements or guidance on how the emergency preparedness procedures and drill and exercise programme shall be designed and what they shall contain. Regarding the requirements for the emergency procedures, the ISM Code references Resolution A.852(20), *Guidelines for a structure of an integrated system of contingency planning for shipboard emergencies*.

4.3.1 ICS Guidance on the Application of the ISM Code

In the Guidelines on the Application of the IMO's International Safety Management (ISM) Code published by ICS (2019), there is a detailed list of what these procedures should include. The procedures shall be present in the shipboard SMS and during drills and exercises onboard they shall be tested and evaluated (ICS, 2019) based on the lessons learnt from the drill or exercise. The list states that the *shipboard procedures* shall include:

- Detailed allocation of duties and responsibilities onboard
- Actions to take to respond and control an emergency
- Methods of communications onboard
- Procedures for notifying the Company and relevant authorities
- Instructions for the communication between ship and shore
- Procedures for handling media and other outside parties

Furthermore, ICS (2019) adds some items that should be considered as they might be required based on the type of emergency situation, which are:

- Standard forms to ensure that the shore side quickly receives essential information
- Checklists for standard actions for both shore side and shipboard personnel
- Checklists specific to each type of emergency situation.

The purpose of the drill and exercise programme is to prepare the onboard crew for emergency situations. However, the programme also fulfils the purpose of ensuring that equipment is operational and that the crew is familiar with it, and to ensure that the crew is familiar with their duties and responsibilities in an emergency (ICS, 2019). The company must ensure that drills are carried out according to the frequency required (Anderson, 2015) according to statutory requirements. The drill and exercise programme shall include a schedule or matrix for when drills and exercises shall be carried out and what should be included (ICS, 2019) in each of these on each occasion.

Even though drills must be conducted, for example, every week or month, there must be some flexibility in the schedule. First of all, as the operations of the ship might vary, the appropriate

time for performing a drill or exercise may vary as well. Drill and exercises shall be planned to minimize interruptions of the crew's rest hours (ICS 2019) and, furthermore, effective drills shall involve as many as operationally possible of the ship's crew (Wu, Jin & Fu, 2014). The drills shall be conducted with seriousness and the company should encourage the shipboard personnel not to see drills and exercises as something that has to be done to fulfil requirements (ICS, 2019).

The programme must ensure that the drills are planned properly and includes simulated exercises (Anderson, 2015), which are scenario-based training where the involved personnel act and respond to the scenario (ICS, 2019), whereas the drills have the purpose to develop practical experience and skills, and practise routines and procedures (ICS, 2019). Both drills and exercises should have a clear objective (ICS, 2019), and based on the objective a scenario and other elements shall be planned. According to ICS (2019) *objectives* might be:

- Familiarization with specific equipment
- Familiarization with procedures or testing new procedures
- Provide practical experience
- Improve skills and knowledge
- Test communication and interaction between personnel

After each drill or exercise there shall be a *debrief* meeting (ICS, 2019) to evaluate it and gain feedback to assess the emergency procedures effectiveness and the crew's capabilities (ICS, 2019). Records for all drills and exercises carried out should be created (Anderson, 2015) and lessons learnt shall be addressed in the SMS (ICS, 2019).

5. Literature Review and Previous Research

5.1 Onboard Drills and Exercises

The importance of onboard drills and exercises is emphasized by Vukonić, Bielić and Russo (2016), Wu, Jin & Fu (2014), and Tac, Akyuz and Celik (2020). Effective onboard training is an essential part of the crew's emergency preparedness (Tac, Akyuz & Celik, 2020; Vukonić, Bielić & Russo, 2016) and in response to an emergency and in maritime accidents, the crew's reliability has a vital role (Tac, Akyuz & Celik, 2020) for the outcome. Another essential part is that the crew onboard should not only gain, but also retain emergency response skills (Smith, Doody & Veitch, 2019) in relation to emergency preparedness. As it is evident that all crew onboard is required to have a basic knowledge of firefighting (STCW, 2010), it can be suggested that this knowledge and skills must be sustained and maintained and not deteriorate (Smith, Doody & Veitch, 2019) in the period in between the training ashore.

However, it is clear that the training carried out ashore lacks the specific characteristics of the vessel and its equipment, a familiarization which is essential for effective emergency response. Furthermore, the crew onboard must train together to achieve a connection and a cohesion as a team (Vukonić, Bielić & Russo, 2016). If the crew is trained as a unified team, they perform better (Vukonić, Bielić & Russo, 2016) not only during drills, but also during an actual emergency onboard. As an example, from a study within Norwegian offshore (Vinnem, 2011), improvements of emergency preparedness have been focused on hardware and technical improvements, but that a high level of emergency preparedness is largely dependent on other, non-tangible, factors such as training, attitudes, motivation and competence.

The purpose of a fire drill is to evaluate the crew's readiness to respond (Wu, Jin & Fu, 2014) to an actual fire onboard. According to Vukonić, Bielić and Russo (2016), successful management for emergency situations depends on organizational factors, and two of those are a well-trained crew and the acceptance of a safety culture. Concerning the training of the crew, Vukonić, Bielić and Russo (2016) emphasize the understanding of the importance of continuous training among crew of all ranks onboard, and that training and drills are taken seriously by the participating crew. Wu, Jin and Fu (2014) also argue that the crew must participate in a drill with 'a positive attitude'.

Although regular fire drills must be carried out on a monthly basis (SOLAS, 1974), the literature suggests that it is the quality of the training (Tac, Akyuz & Celik, 2020; Vukonić, Bielić & Russo, 2016), which is the most important factor rather than the frequency. The quality of drills carried out will vary, and some might be conducted only as musterings (Oltedal & McArthur, 2011) and therefore lack the actual practise and realistic scenario, which is also required according to SOLAS Regulation III/19.4.1 (SOLAS, 1974). The training and drills might be insufficient due to a poor quality of the training carried out, but also due to that drills are postponed or disregarded (Tac, Akyuz & Celik, 2020) due to lack of time, work overload or a trade-off between efficiency and safety practices (Oltedal & McArthur, 2011). Overall, the shipping industry faces challenges of increased competition and efficiency demands (Fenstad,

Dahl & Kongsvik, 2016) as many other industries. Shipowners and shipping companies are therefore required to balance the demand for efficiency and the fulfilment of international and national regulations, which may negatively affect the safety climate onboard (Fenstad, Dahl & Kongsvik, 2016). Fulfilling the safety procedures stipulated in the SMS, while still fulfilling the owner's or company's efficiency demands, is also challenging (Fenstad, Dahl & Kongsvik, 2016) for the crew itself. Finally, it can be suggested that the increasing number of administrative tasks under the SMS (Kongsvik, Størkersen & Antonsen, 2014) gives an increased workload that may lead to even less time left to perform core tasks or training.

5.2 Safety Culture and Onboard Training

Vukonić, Bielić and Russo (2016) argue that there are organizational factors influencing the crew's level of emergency preparedness and management of emergency situations, which are not purely related to onboard training and drills. The research suggests that the safety culture onboard is a very important component for emergency preparedness (Lu & Yang, 2011; Tac, Akyuz & Celik, 2020). However, as found by Fenstad, Dahl and Kongsvik (2016), the safety climate onboard, which is a part of the safety culture, is often negatively affected by efficiency demands. On the reverse side, the lack of a safety culture and safety awareness onboard has also a negative impact on effective (Tac, Akyuz & Celik, 2020) emergency preparedness. This argument is supported by Lu and Yang (2011), which in their study found that there is a positive association between emergency preparedness and safety behaviour, participation and compliance. The research suggests further that the problem does not appear to be the lack of regulations regarding emergency preparedness, but rather the incomplete *implementation* (Tac, Akyuz & Celik, 2020) of these regulations at an operational level. So even though the quality of the regulations may have some influence on the safety climate onboard, it is not as great as the negative effect of efficiency demands (Fenstad, Dahl & Kongsvik, 2016). Furthermore, a poor or absent safety culture (Tac, Akyuz & Celik, 2020) can be one of the reasons for postponing or back-logging drills. That is because ultimately, the quality of the drills conducted onboard and ensuring that they are carried out, is the master's and the ship management's responsibility (Oltedal & McArthur, 2011).

It can be assumed that the level of the safety culture and implementation of safety procedures in the company and onboard the ship is reflected in the priority drills and exercises are given and the level of motivation they are carried out with. The aim of the ISM Code is to generate a safety culture within the shipping industry (Anderson, 2015), however, there is a wide spread of definitions of what safety culture is (Oltedal & Lützhöft, 2018). Some argue that it is a subculture to organizational culture (Oltedal & Lützhöft, 2018), while others would view it as the way the organizational culture deals with safety (Oltedal & Lützhöft, 2018). Overall culture is, according to the most common model, the norms, values, assumptions and artefacts (Oltedal & Lützhöft, 2018) within a group or an organization. The culture will therefore affect everything and everyone within the organization (Oltedal & Lützhöft, 2018) and the culture will often not only differ between shipping companies, but also different vessels within the same company will have their own culture (Oltedal & Lützhöft, 2018).

5.3 Safety Culture and Regulations

There are a number of articles and literature covering the link between the ISM Code, the safety culture onboard and the compliance with the code and the SMS (Kongsvik, Størkersen & Antonsen, 2014; Fenstad, Dahl & Kongsvik, 2016; Størkersen, Antonsen & Kongsvik, 2017; Batalden & Sydnes, 2014; Bye & Aalberg, 2020; Oltedal, 2011). Başţuğ, Asyali and Battal (2020) state that the implementation of the ISM Code onboard and ashore is inadequate due to factors such as lack of motivation for safety culture and conflicting perceptions between shore management and shipboard personnel, among others. Overall, it appears that there is a mismatch between the intention of the ISM Code and the way that the shipping industry has adopted it (Størkersen, Antonsen & Kongsvik, 2017). The intention of the ISM Code was to create a safety culture, self-regulation within the shipping companies and a process of *continuous improvement* (Størkersen, Antonsen & Kongsvik, 2017). However, the industry has instead responded by administrative structures, adoption driven by compliance and minimum standards for safety (Størkersen, Antonsen & Kongsvik, 2017) and contributing to a bureaucratic culture where the goal of the SMS is compliance with external requirements (Størkersen, Antonsen & Kongsvik, 2017).

Looking at the implementation of the ISM Code onboard in relation to a safety culture, regulators see it and the SMS as important components (Kongsvik, Størkersen & Antonsen, 2014) for developing a safety culture. However, the opinions and attitudes of the crew onboard the vessels are more complex (Kongsvik, Størkersen & Antonsen, 2014; Størkersen, Antonsen & Kongsvik, 2017; Bye & Aalberg, 2020) than this. The crew onboard perceive the SMS as a 'necessary evil' (Kongsvik, Størkersen & Antonsen, 2014), that contains too many rules (Bye & Aalberg, 2020) and believe that it reduces the safety management onboard to detailed ruled (Størkersen, Antonsen & Kongsvik, 2017). The procedures in the SMS are often seen as irrelevant and impractical (Bye & Aalberg, 2020) and not adjusted to the specific conditions or circumstances onboard, so when adopting them, the crew see themselves as violating the procedures (Kongsvik, Størkersen & Antonsen, 2014). In the study by Bye and Aalberg (2020), over half of the respondents in the study answered that they do not always follow the procedures. A common view among the crew onboard in the study was that the procedures are designed for the company to move the responsibility from them to the Master and the crew in case of an incident (Bye & Aalberg, 2020).

Despite the crew's criticism towards the SMS, studies have found that the ISM Code contributes to an increased safety awareness and safety level among shipowners, and valuable routines such as emergency training on a regular basis (Størkersen, Antonsen & Kongsvik, 2017). Regular emergency training is reportedly an appreciated part of the SMS among the crew onboard (Kongsvik, Størkersen & Antonsen, 2014; Fenstad, Dahl & Kongsvik, 2016; Bye & Aalberg, 2020). Furthermore, safety procedures regarding, for example, emergency preparedness are quite specific and violations of them are detected easily (Fenstad, Dahl & Kongsvik, 2016). Emergency procedures and checklists appear to be generally considered as

useful and important and the emergency procedures *"seemed to be perceived as resources for action […] not as a means of control"* (Bye & Aalberg, 2020).

The above indicate that even if the SMS per se is regarded with scepticism by the onboard crew, and while the ISM Code struggles with being fully implemented in the industry and contributing to a safety culture, the emergency preparedness procedures are appreciated and highly valued by the crew. This fact is in contradiction with the studies that report that drills and exercises are not properly carried out onboard. If the crew values the procedures and views the compliance with them as important, drills would be properly carried out and not postponed. It might be that the quality of the procedures influences the quality of the drills, but at the same time the emergency preparedness procedures in the SMS must fulfil the regulations in SOLAS, therefore setting a minimum standard for these procedures. The purpose of the drills is to evaluate the crew's emergency preparedness, as well as the established emergency procedures in the vessel's SMS and the content of the procedures might also influence the onboard drills and exercises. Savari, Cevikcan, Ustundag and Celik (2018) argue that there is a strong link between the performance in an emergency and the safety procedures in the SMS relating to emergency preparedness. Furthermore, the ISM Code requires that drills and exercises shall be properly evaluated, and lessons learnt identified (ICS, 2019). How this is regulated in the SMS and the amount of *administrative work* required for this might also affect the effectiveness of the drills. Even though the regular drills per se are appreciated, the administrative work after the drills might not be.

However, the focus of the articles stating that emergency preparedness procedures are appreciated by the crew (Kongsvik, Størkersen & Antonsen, 2014; Fenstad, Dahl & Kongsvik, 2016; Størkersen, Antonsen & Kongsvik, 2017; Batalden & Sydnes, 2014; Bye & Aalberg, 2020; Oltedal, 2011) focused on the ISM Code and SMS as a whole, and not specifically emergency preparedness. It is therefore not possible to determine why the crew deem the emergency preparedness procedures and following them to be more important than other procedures. It may be the fact that these procedures are regulation-based and violations of them are easily detected (Fenstad, Dahl & Kongsvik, 2016) or the fact that the crew see the importance in retaining their skills and being well prepared in the event of an emergency situation. Finally, in these studies it is not specified what parts of the procedures are appreciated as they include more than a drill and exercise programme, such as for example specific instructions and checklists (ICS, 2019).

Of the previous research on emergency preparedness, none has solely focused on fire safety training. In relation to that fires and explosions onboard represents a large percentage of maritime accidents (Baalisampang et al., 2018) and these being more mortal than other accidents (Weng & Yang, 2015), this *research gap* is necessary to study how the crew onboard trains to achieve fire emergency preparedness. Based on previous literature on regulations, implementation, and compliance in the maritime industry, it is in relation to this relevant to investigate what the crew and shore management believe is important for an effective

firefighting organization onboard and how this correlate to the existing rules and regulations. As it has been identified by Størkersen, Antonsen and Kongsvik (2017) the regulations have little or questionable effect on the safety onboard, based on this finding this study will furthermore aim to identify the factors which affect the fire safety training onboard.

6. Results and Analysis

6.1 Fire Safety Training Skills

Based on the data gathered from the *interviews*, it can be stated that the skills that are considered relevant in relation to fire safety training and fire drills fall under three main categories, being *Practical* skills, *Theoretical* skills and *Social* skills. The Practical skills, refer mainly to the use and familiarization with the equipment and systems onboard, to the use of the fireman's outfit and gear, as well as other aspects referring to ship-specific knowledge and cargo-specific knowledge. In relation to the Theoretical skills, these cover aspects relevant to fire theory, risk assessment, risk awareness and knowledge of applicable Rules and Regulations, while some Social skills that appear to be relevant to fire safety training are teamwork, leadership and communication. A combination of the above skills appears to be ideal for the crew to obtain through fire safety training, and while an initial categorization of skills may be useful, it can be suggested that skills cannot be viewed in isolation as they are often interrelated and intertwined. The identified skills are analysed in conjunction with the relevant requirements under the applicable *Regulations*, such as SOLAS, the ISM Code and the STCW Convention, as well as, with relevant Theories.

6.1.1 Practical Skills

The practical skills that are considered important by the majority of the interviewees are related to the use of the equipment and systems onboard, the fireman's outfit and gear, as well as the acquisition of ship-specific and cargo-specific knowledge. The majority of the interviewees stated initially that the acquisition of said skills is also required under SOLAS and the ISM Code, according to which the crew must be familiar with the use of firefighting equipment and appliances. Furthermore, the interviewees stated that according to the SOLAS and the ISM Code, the crew must develop practical experience and skills and practise routines and procedures and that fire drills are the method for doing so. That said, based on the applicable Regulations, the practical skills that the crew must develop may refer more specifically to the use of water or other appliances for fire extinguishing, to ventilation control, to firefighting involving dangerous goods, to communication and coordination during firefighting and to the management of injured persons. Furthermore, training relating to fire detection and firefighting must be done through practical exercises, also in darkness, in realistic conditions and by using the relevant equipment. That said, all interviewees confirmed that fire drills are conducted regularly onboard and that during fire drills, the crew trains in using the relevant firefighting equipment and systems onboard. However, some interviewees argue that drills are not always carried out realistically (e.g., without real smoke), for either commercial reasons such as the carriage of cargo or passengers onboard or due to lack of time.

6.1.1.1 Equipment and Systems

From the data collected through the interviews, it appears that all interviewees believe that through fire safety training and fire drills, the crew and officers onboard need to first of all familiarize themselves with and learn how to use the *equipment and systems* onboard. The proper use, functionality, as well as the maintenance of the equipment on board is indeed of crucial importance and lack of that can result in immense damage to property and life. That said, some interviewees stated that fire onboard may spread in the blink of an eye, therefore

there is a need for the equipment to be available for immediate use and the crew is required to be able to use it effectively without any hesitation. When it comes to the practical skills required in relation to fire safety training, the majority of the interviewees stated that the crew is being trained in order to be able to act efficiently to prevent fires, contain fires and extinguish fires. The interviewees stated further that according to SOLAS, fire drills are the appropriate form of fire training in order for the crew to be acquainted with the equipment and systems onboard. Fire drills are therefore conducted in order to prepare the crew for their tasks in case of a fire onboard, for using different types of firefighting appliances and fire extinguishers and for using the fireman's outfit and gear. That said, all the interviewees having onboard working experience, confirmed that they had received training in the form of fire drills when they used the relevant equipment and systems, as well as, participated in basic and advanced firefighting courses in accordance with the STCW Convention requirements. Therefore, the data show that the method of their training is indeed in accordance with the applicable regulations, however, some deficiencies emerged in relation to the content of the training.

More specifically and based on the results from the interviews, the majority of the interviewees referred to the need for the crew to have practical skills in relation to the use of fire hoses and fire pumps and to be able to use fixed, as well as portable firefighting equipment for fire extinguishing. A small percentage of the interviewees mentioned further that in practice the crew rarely trains with *pressurized hoses*, due to several reasons such as the risk of leakage. In relation to this, one of the interviewees with experience from Ro-Pax vessels, mentioned further that an external auditor questioned the crew on whether they train with pressurized hoses and the answer was negative. This however did not appear to come as a surprise to the interviewee, who stated that they were well aware of the fact that pressurized hoses are rarely used during fire drills. This aspect was also confirmed by more interviewees, also from the tanker sector, who had identified a lack of training with pressurized hoses and mentioned different reasons for that, such as the risk of leakage during training.

In addition to the above, another interviewee stated that another deficiency in relation to the use of systems available onboard for fire safety and firefighting is related to *ventilation* and its use for over pressurizing certain compartments in order to direct the smoke. However, only one interviewee with experience from Ro-Pax vessels mentioned this aspect, which appears to be omitted by the majority of the interviewees, especially the ones from the tanker sector. The same omission appears to be in relation to training on the operation, testing and use of *fire doors* during fire drills conducted onboard. It appears that only a very small percentage of the interviewees, mainly having working experience from Ro-Pax vessels, mentioned that fire doors are included in the fire safety training and are important for the crew to know how to operate them. However, the majority of the interviewees did not consider this aspect at all and made no reference to fire doors during the interview. That appears to be in contradiction with the requirements under the SOLAS convention, stating that the operation and use of fire doors needs to be part of every fire drill. Another aspect mentioned by several interviewees was the need for training with different types of *fire extinguishing appliances*, such as water, foam and

powder and having knowledge on when to use which and for what reason. This appears to be also connected to the type of fire (electric, chemical etc.) and would require for the crew to also have cargo specific knowledge, as well as basic theoretical knowledge about fire theory. In relation to the above, the interview data suggests that the majority of the interviewees had indeed experienced the use of different extinguishing appliances during fire drills, which is also in harmony with the requirements under the SOLAS and the ISM Code.

6.1.1.2 Fireman's Outfit and Gear

Another aspect that was discussed during the interviews, was the part of the fire drills that refers to the use of the fireman's *outfit and gear*, such as the *Breathing Apparatus* (BA) device, as provided also under the SOLAS Convention. However, notice can be given to the remarks made by one of the interviewees, who stated that even though using the fireman's outfit and gear is very often part of the drills and fire training, the crew is frequently not fast enough in getting dressed and ready. This was a remark by one of the interviewees with experience from the tanker sector, who further stated that the crew is often too relaxed during fire drills and do not often consider the *speed* of performing their tasks, such as gearing up on time. The interviewee expressed further a concern on whether the crew would actually be able to gear up fast enough in case of an actual fire and the fact that the way that the crew is often gearing up during a fire drill does not reflect a realistic situation.

Another aspect mentioned by one of the interviewees, was that the crew might not always pick the right *size* of gear, such as safety boots and helmets. It was implied that the reason behind that was that this aspect is not often considered by the crew during a fire drill. That said, picking the wrong size of gear, such as boots, is considered a factor that may result in personal injuries, such as, slips, trips and falls, which are the most common cause of maritime injuries (Gard, 2020). Important appears to be also the acquisition of skills in relation to the use of the *communication equipment* of the gear, such as microphones and radios. Several of the interviewees stated that they have encountered often issues with the proper use of the communication equipment. One of the interviewees mentioned specifically that issues have arisen in relation to the correct use of the radio equipment and stated that the crew is often either miscommunicating in relation to which frequency to use or are using the equipment incorrectly. This appears to have a critical effect on the communication during fire drills, resulting in confusion and miscommunication.

6.1.1.3 Ship-Specific Knowledge

Further to the above, some of the interviewees also believe that an essential part of their practical training is relevant to *ship-specific knowledge.* That is because in situations, like fire onboard, the crew needs to be able to, first of all, find their way around the ship 'even with a blindfold' in order to save time during an emergency, such as fire onboard. Equally important appears for the crew to be able to know the locations of the *alarm buttons* and *muster stations* and the *location of the relevant equipment* onboard, such as, *fixed firefighting systems*. Most of the interviewees stated that ship specific knowledge is not only important due to the differences

in structure and ergonomics between different vessels, but also due to the difference in *procedures* from ship to ship. One of the interviewees from the passenger sector stated further that the new crew often has familiarization training when they first join and that includes going around the vessel as a 'double' with one of the officers.

When referring to the contents of ship-specific knowledge, these appear to be relevant to the *location* and use of the ship's equipment and the systems onboard, which may vary from ship to ship. The same applies also in relation to the location and use of fire doors, which one of the interviewees stated that it is rarely included in fire drills. Another interviewee stated that ship-specific knowledge includes the crew getting well acquainted with the different *areas* onboard, such as the accommodation areas, the engine room areas, the cargo holds etc, and being aware of high-risk areas onboard when it comes to fire risks. Knowing the location and particulars of each area appears to be indeed crucial in case of a fire onboard, as different areas are subject to different hazards, different risks and different actions that need to be taken in case of an emergency. As fires often include smoke, the need for the crew to acquire ship-specific knowledge and being well familiar with the different areas onboard, is crucial in order for them to be able to operate in the darkness and while under pressure. Another important aspect mentioned by one of the interviewees, is that ship-specific knowledge is naturally one of the very few areas that cannot be trained in training centres. Therefore, the interviewee believed that obtaining ship-specific knowledge can only be done through regular fire safety training and during fire drills onboard.

6.1.1.4 Cargo-Specific Knowledge

When the interviewees were asked about *cargo-specific knowledge* and the risk of fire, they all agreed that cargo-specific knowledge is also considered very important as part of fire safety training. This knowledge refers to different aspects of how to practically handle regular cargo, as well as dangerous cargo and to avoid fire risks in relation to cargo carried onboard. More specifically it includes knowledge and skills on how to load, discharge, stow and secure cargo, how not to mix or place specific cargoes next to each other to avoid the risk of fire and how to contain and extinguish fires on different cargoes, such as chemicals. Furthermore, all interviewees agreed that it is important to also have knowledge on how to assess, contain and extinguish different types of cargo fires, e.g., chemical, electrical etc. and that this is not often part of their training. They stated further that cargo-specific knowledge is required when assessing the most appropriate fire extinguishing method, such as use of *water, foam or powder* depending on the type of cargo fire. Except for regular types of cargo, several interviewees referred to Dangerous Cargo carried onboard. The different dangerous cargo categories mentioned by the interviewees appear to be relevant to provisions included under SOLAS in relation to dangerous goods, as well as the provisions under the *International Maritime Dangerous Goods Code* (IMDG Code) and MARPOL.

Based on the interviews, it can be stated that the crew considered the skills and knowledge related to the handlings of Dangerous Goods as especially important for individuals involved

in cargo operations, where there is a need for specialized training in relation to the handling of such cargo. Some interviewees stated that this knowledge touches upon the requirements for handling, loading and stowing different classes of Dangerous Goods, of risk awareness and theory behind different types of fires involving Dangerous Goods and practical actions to minimize potential damage and/or injury in case of e.g., fire. Interestingly enough, very few of the interviewees mentioned obtaining cargo specific knowledge as an important skill that crew usually obtains through fire safety training without being specifically asked about it. However, interviewees with experience from the tanker industry stated that cargo-specific knowledge and skills are relevant also in relation to the handling of *chemicals* onboard. They stated further that when it comes to fire safety training, training with chemical suits is sometimes included in the fire drills, however, this appears to be done only on vessels where chemicals are actually carried regularly as cargo onboard. On the other hand, interviewees with experience from the passenger sector and from Ro-Pax/Ro-Ro vessels referred to the risk of fire in *reefer units.* This appears to be a commonly encountered fire risk hazard onboard this type of vessel due to the third-party electrical equipment within said reefer units. The reason mentioned was that the electrical equipment cannot be checked by the vessel and appears to often lack the required quality and maintenance standards. The interviewee further stated that the Ro-Ro/Ro-Pax vessels that carry reefer units create specific risk assessments for said cargo and stated that their crew is required to possess the relevant skills to understand and utilize said documentation.

Practical Skills	**Identified Areas of Interest**
1. Equipment and systems onboard	• Training with pressurized hoses • Operation and use of fire doors • Use of ventilation onboard • Use and functionality of communication equipment (radios, etc.)
2. Fireman's outfit and gear	• Use and functionality of the communication equipment (microphones, etc.) • Use and functionality of the breathing apparatus • Speed of gearing up • Size of outfit and gear
3. Ship-specific knowledge	• Location of muster stations • Location of alarm buttons • Location of fixed firefighting equipment • Ship-specific procedures
4. Cargo-specific knowledge	• IMDG Code (loading, stowing, securing and discharging of dangerous goods) • Chemicals and use of chemical suits • Use of foam, water or powder depending on the type of cargo • Reefer trailers and electrical fires

Table 2. *Practical Skills and Identified Areas of Interest*

6.1.2 Theoretical Skills

Another set of skills that several interviewees mentioned as important for the crew to obtain through fire safety training is Theoretical skills. In relation to Theoretical skills, the majority of the interviewees mentioned the need for acquiring *Knowledge about the Theory of Fire*,

obtaining skills relevant to *Risk Awareness and Risk Assessment* and knowing about the relevant *Rules and Regulations*. Furthermore, according to the majority of the interviewees, fire safety training should ideally be a combination of theoretical and practical training and should contain both theoretical and practical drills. They further believed that a good foundation of Theoretical Skills can be complementary to the Practical skills obtained through fire safety training and as a basis to understand their tasks and their purpose.

6.1.2.1 Knowledge about the Theory of Fire

When it comes to theoretical skills, some of the interviewees consider it important to obtain some basic *knowledge about the theory of fire*, as well as, knowing the theoretical aspects of how fire behaves on different types of cargo, such as Dangerous Cargo. This aspect appears to be important in order to be able to identify different types of fires, such as chemical, electrical etc., to be able to make an appropriate risk assessment and to choose the correct extinguishing appliance, such as water, powder or foam. That said, one of the interviewees stated that theoretical skills relating to the theory of fire would entail the crew obtaining knowledge about the three elements of fire and explosion (*the fire triangle*), being fuel, heat and oxygen. The interviewee mentioned further that the crew needs to be able to recognize different *ignition sources*, such as chemical and biological and have theoretical knowledge in relation to aspects such as flammability, burning temperature and speed of fire on different materials. The interviewees stated that obtaining this type of theoretical knowledge can lead to an increased risk awareness when handling different types of cargoes, such as *Dangerous Cargoes*, that might be explosive, toxic or poisonous. Other types of cargoes, such as reefer trailers, might also be considered high risk for fire onboard Ro-Pax vessels and therefore it is important for the crew onboard to be familiar with the risks of electrical fire and applicable means for extinguishing it.

6.1.2.2 Risk Assessment and Risk Awareness

Having a basic theoretical knowledge about fire appears to be also important in order to obtain skills relevant to *risk assessment* and *risk awareness*. That said, the data suggests the importance for the crew to obtain through fire safety training and drills, the theoretical knowledge required in order to be aware and identify potential fire hazards. That is considered necessary by some interviewees in order to enable the crew to act proactively and prevent fires onboard from occurring. Said theoretical skills relating to fire risk awareness and risk assessment can also be useful when identifying areas onboard where fires usually occur, such as engine rooms, cargo decks and accommodation. Several interviewees stated further that the crew needs to be acquainted with the most common causes of fire onboard vessels, such as oil leakage in the engine room, hot work (welding etc.), overheating, cigarettes and electronic devices (batteries, chargers etc.). Based on the data obtained from the interviews, it appears that common methods for obtaining these theoretical skills and knowledge is through *safety videos (video learning)*, *theoretical fire drills*, *safety bulletins* and *safety toolbox talks*. In relation to video learning and theoretical fire drills, even though some of the interviewees stated

that too much theory might not be helpful, the majority of the interviewees prefer a balanced combination of theoretical and practical fire drills.

Some of the interviewees mentioned further that *video-learnings*, *theoretical drills* and *safety tool-box talks* are more efficient and useful when focusing more on previous incidents and lessons-learned in order to combine theory with a more practical approach. Emphasis on lessons learned as an important tool for obtaining theoretical skills was mentioned by several of the interviewees, especially those with experience from the shore side organization. The interviewees further suggested that the development of theoretical skills in relation to risk awareness and risk assessment is done more efficiently when reference is made to previous *real-life incidents*. The reason for that appears to be that the crew can relate more with real-life scenarios when discussing lessons-learned than when referring to fictional scenarios Some interviewees stated that the crew discusses occasionally about potential risks and prior experiences, and knowledge is communicated and exchanged during briefings and debriefings. Identifying and managing risks is also a requirement under the ISM Code and relevant risks in relation to fire safety may refer to the health and safety of crew or passengers, to the property onboard, as well as, to the environment.

6.1.2.3 Rules and Regulations

When it comes to obtaining theoretical skills relating to *Rules and Regulations*, it appears that not all interviewees consider it important for the entire crew to be fully aware of the applicable rules and regulations in relation to fire safety and training. Most of the interviewees believe that crew in lower ranks, such as ordinary seamen and able seamen are only required to have a basic knowledge and understanding of rules and regulations in order to be able to comprehend the purpose behind their tasks. However, the majority of the interviewees consider it important for the Master and the officers onboard, as well as, for the individuals specifically involved in fire safety, such as fire chief, to have a high level of knowledge of the applicable rules and regulations in relation to fire safety. That is due to the fact that their duties usually involve making sure that the procedures onboard adhere to the applicable Rules, Regulations and standards.

Some of the interviewees mentioned further that having knowledge of the applicable Rules and Regulations is required from the *officers*, as they are also involved in the process of decision-making. Therefore, they believe that in order for the officers onboard to make sound decisions, they need to understand the requirements which derive from the applicable Rules and Regulations. This finding may be of interest from different perspectives as it highlights the different types of skills that officers are required to obtain and maintain while working onboard, as well as the impact that the existence or lack of these skills may have in the quality or content of the fire safety training onboard. It also highlights how dependent the quality and content of the fire safety training and fire drills is on the skills and knowledge level of the management and of the officers onboard. Interestingly enough, the above finding is even more relevant considering that it derives from the opinions of interviewees who are working as officers or

Masters onboard. Some of the interviewees expressed, however, the opinion that Rules and Regulations are more reactive than proactive and often can be very square or black and white, leaving little room to case-by-case assessments and interpretations. Some also suggested that the amount of information in the Rules and Regulations appears to be massive, which makes the Regulations complicated and disengaging, while others suggested that some requirements appear to be outdated and should be modernized.

When asked about whether having theoretical skills and knowledge of the applicable Rules and Regulations would increase the *safety culture* onboard, the replies were not unanimous. Some of the interviewees appear to consider that having such knowledge may increase the safety culture onboard, especially on vessels where there is no pre-existing safety culture, while others suggested that adherence to Regulations may be more about paperwork and not always about the actual safety culture onboard. However, while the opinions about the impact that Rules and Regulations may have on the safety culture onboard varied, all the interviewees stated that officers onboard need to have a good knowledge of the Rules and Regulations as this knowledge is closely connected to conducting quality fire safety training.

Theoretical Skills	**Tools to Develop Theoretical skills**
• Theory of fire • Risk awareness • Risk assessment • Rules and regulations	• Video learning and movies • Theoretical drills • Safety bulletins • Safety toolbox talk • Lessons learned

Table 3. *Theoretical Skills*

6.1.3 Social Skills

Another set of skills that the interviewees considered important for the crew to obtain through fire safety training is social skills such as *teamwork, communication, leadership, stress management and crowd management.* Several of the interviewees stated that the crew onboard is usually exposed to several sources of stress, not only due to the high demands of their work, but also due to the uniqueness of their work situation. That said, the crew onboard often faces challenges such as isolation, long periods away from home and separation from their families and friends, as well as heavy workload and time pressure. The combination of the above factors can result in loneliness, fatigue and stress, which may contribute negatively to the seafarers' performance of their tasks, therefore increasing further the need to develop social skills onboard. These skills are also considered particularly important when it comes to dealing effectively with emergencies, such as fires, onboard where the crew is required to collaborate and communicate effectively with each other and work as a team in order to extinguish the fire.

6.1.3.1 Stress Management and Teamwork Skills

In more detail, the factor of *stress* was mentioned by one third of the interviewees as being one that might affect the crew significantly when a casualty, such as fire, occurs onboard. However, the majority of the interviewees believe that in such stressful situations, knowing how to work effectively as a team, being familiar with not only the procedures, but also with each other and knowing how to communicate, is of crucial importance for the outcome. One of the interviewees mentioned further that when going to the sea you need to understand how alone you are and that help is usually far away. Therefore, in case of an emergency, such as a fire, onboard, the crew is often faced with additional stress due to the remoteness of their location and the fact that getting help might take several hours. When discussing with the interviewees about the impact of stress in such situations, a strong interrelation between *stress management, teamwork and communication* appears to emerge. It appears that crew onboard may handle better stressful situations when there is a strong team spirit, good collaboration and good communication onboard. That seems to be also due to the fact that the crew can depend on the team during a stressful situation, which may reduce the stress of having to deal with an emergency onboard alone. This is particularly important considering that during an emergency, such as fire, onboard one or several crew members may be injured, absent or missing, thus making the importance of the team even more crucial for a successful outcome. On the other hand, effective stress management appears to be crucial also in order to 'protect cognitive performance' and maintain the 'ability to communicate clearly' (Fjeld, G.P, Tvedt, S.D., 2020). In relation to this, some of the interviewees mentioned that fire drills prepare the crew for dealing with stressful situations and enable them to acquire the skills and calmness that will be needed to maintain their ability to perform their tasks and communicate while being under severe pressure.

A large percentage of the interviewees believe further that training specifically during fire drills cultivates the team spirit and improves the communication, teamwork and collaboration onboard. During a fire drill, the crew is normally divided into smaller teams and each team is assigned with different tasks according to the chosen scenario. In order to perform these tasks effectively, the crew is required to collaborate and communicate with each other. Therefore, some interviewees stated that during a fire drill the crew becomes more *familiar* with each other and working together towards the same goal cultivates the team spirit and the ability to communicate. Furthermore, by working together as a team during a fire drill, the crew is able to identify each other's *strengths and weaknesses*, which enables them to foresee possible implications when working as a team and address them at an early stage. Some interviewees stated further that repetition of tasks during fire drills creates a 'muscle memory'. This 'muscle memory' appears to be especially important when the crew is dealing with stressful situations, as their body will remember the tasks that need to be performed regardless of the stress that their mind is under.

6.1.3.2 Communication Skills

Communication appears to be also one key element, mentioned by most of the interviewees, for having a successful and effective fire safety training onboard. When looking in more detail into the aspect of communication, the majority of the interviewees stated that the crew onboard needs to obtain communication skills through fire safety training and fire drills. From the data obtained from the interviews, it appears that of equal importance to the officers and crew onboard is the clear *distribution of roles and responsibilities* during a fire drill. The clear distribution of roles and responsibilities should therefore be clearly communicated by the fire drill leader during the briefing before the commencement of the fire drill. According to some of the interviewees, good communication skills during a fire drill can be understood better by referring to the use of *clear, simple and precise language* and the use of *standardized phrases* in order to avoid miscommunication. Some interviewees stated that the crew sometimes encounters issues due to the fact that communication is conducted in the official working *language* onboard, or otherwise in English, which is often not the native language for most crew members. That said, a minority of the interviewees stated that some crew and officers onboard appear to feel more comfortable conducting fire drills in their *native language*, instead of conducting it in English. When asked about the root cause of this, it appears that some crew members onboard might consider their English language knowledge not fully adequate to describe complex situations under stress or duress and the belief that in case of an actual fire onboard, some crew members would choose to communicate in their native language. Interestingly enough, the remark about the possible inadequacy in relation to the knowledge of the English language was only mentioned by younger interviewees.

In contrast, interviewees with more senior positions and longer working experience suggested that the use of the English language is rarely a problem among the senior officers onboard. Therefore, it appears that the aspect of *seniority* is a factor in relation to the choice and ease of using foreign languages, such as English, for communication onboard. However, what was mentioned by some interviewees was that miscommunication due to *language barriers* has been identified when working onboard vessels with mixed crew and different nationalities. According to the interviewees, some nationalities in the East appear to be often more prone to language barriers than crew from the West. This appears to be connected also to the difference in *mentality and culture* between crew from the East and crew from the West, which may create additional communication barriers. Other interviewees suggested that differences in shore-side training between different nationalities can emerge also due to the potential difference in training conducted in training centres in the East compared to the West. These differences appear to have also an impact on communication between mixed crew, due to the different backgrounds, points of view, culture and mentality.

Another important aspect of communication that appears to be raised by some interviewees is the *information flow* and the importance of knowing what to communicate, to whom and when in case of a fire onboard. This appears to be in relation not only to internal communication between crew onboard and with the shore management, but also external communication with

third parties such as fire brigades, emergency service providers and the media. That said, emphasis should be given to the provisions under the ISM Code, which state that crew training must include providing guidance to the crew on how to communicate and interact onboard during an emergency, how and when to notify the Company and the relevant authorities and how to handle *media* and external parties (ICS, 2019). From the interviews conducted, it appears that such training is more common for officers working onboard Ro-Pax vessels, and this type of training had not been experienced and/or mentioned by any of the interviewees working on tankers. The reason behind this may be the usually higher media attention to incidents involving passengers, compared to incidents involving cargo and the need for crew to be able to manage the information flow in such cases. However, due to the high media attention involving incidents, such as major oil spills from tankers, it may be relevant to consider the lack of training in handling media and other external parties by crew and officers working onboard tankers.

Furthermore, communication training is also essential when it comes to *crowd management* on board Ro-Pax vessels, which was mentioned by only one of the interviewees with experience from this sector. However, this type of training appears to be crucial, as passengers onboard may react unpredictably during a stressful situation and therefore it is essential for the crew to receive special training in order to be able to manage the crowd. The interviewee stated further that officers and crew working onboard passenger vessels are often trained in crowd and crisis management in order to be able to communicate with the passengers effectively, spread the necessary information and avoid panic in case of a fire onboard. However, obtaining skills in relation to crowd management and crisis management was not mentioned by any of the interviewees with working experience from tankers. This seems to be logical considering the lack of passenger interaction onboard tanker vessels, therefore such skills may not be considered as relevant or important for this sector.

6.1.3.3 Leadership Skills

Another social skill that was mentioned by several interviewees in relation to fire safety training was *leadership*. According to Fjeld et al. (2018) leadership, being one of the five Non-Technical Skills, often includes skill content such as ‘using authority and assertiveness, providing and maintaining standards, planning and prioritizing and management of workload’ (Flin et al. 2008). Furthermore, according to the STCW ‘Manila Amendments’, leadership skills are required by deck and engine officers due to the importance of such skills not only for the officers themselves, but also for those in lower ranks collaborating with them. Having said that, several interviewees stated that individuals onboard who hold more senior positions, such as the officers, the fire drill leaders and the Master, need to possess leadership skills in order to guide, encourage, inspire and motivate the crew onboard. In more details, some of the interviewees mentioned that having a management onboard with good leadership skills would assist in the creation of a stronger safety culture, where they ‘lead by example’ when it comes to safety overall, but also fire safety.

When discussing the topic of what a good management onboard would offer, the interviewees mentioned that senior officers and the Master should be able to provide *guidance* in relation to the Company policies and procedures, as well as applicable Rules and Regulations. They must also be able to take initiatives and *action* when seeing non-conformities and risk hazards, but also be able to accept *criticism*. That said, some interviewees mentioned that when the crew is able to provide constructive criticism to the management onboard regardless of rank, this is also a sign of a strong safety culture. The above is particularly important when it comes to fire safety training, where a management with strong leadership skills is able to provide guidance to the crew in relation to fire safety and the relevant company procedures and applicable Rules and Regulations. It is also essential for taking immediate action in relation to fire hazards and non-conformities and being able to accept criticism for non-safe practices onboard.

Another aspect mentioned by some interviewees is that the quality of the fire drills is very often dependent on who is the *drill leader* onboard. The interviewees mentioned further that a good drill leader must be able to communicate effectively and organize the team, while at the same time being able to make decisions, delegate, multitask and motivate. When it comes to motivation, the interviewees mentioned that the crew onboard tends to have higher engagement in fire drills when drill leaders are creative and produce realistic fire drill scenarios. Furthermore, they expressed the opinion that good drill leaders are the ones who make sure that the entire crew is actively involved during a fire drill and practising in how to work effectively as a team and where everyone is able to provide feedback and ask questions. Finally, one of the interviewees mentioned that a management onboard with strong leadership skills is the one who is able to handle effectively any potential resistance to change. Areas where resistance to change was mentioned during the interviews was the use of new technology and of new systems as part of a digitalization initiative within the company, as well as the promotion of a safety culture.

6.1.3.4 Social Skills and Non-Technical Skills

In summary, the social skills mentioned by the interviewees in relation to fire safety training can be compared to the *Non-Technical Skills (NTS)* reviewed by Fjeld et. al (2018), where the five identified NTS were leadership, communication, workload management, decision-making and situation awareness. In relation to communication skills, all the interviewees considered that these are important for the entire crew to obtain through fire safety training and that crew should be able to communicate effectively both internally and externally. However, leadership and decision-making skills were considered important mostly for the Master, the officers and the fire drill leaders and not for the rest of the crew. On the other hand, workload management was not directly mentioned by any of the interviewees, however, aspects of workload management such as problem solving, prioritization and 'staying calm' (Fjeld et al., 2018) were identified as relevant to fire safety training.

That said, some of the interviewees mentioned that during a fire drill or an actual fire onboard, it is of crucial importance to remain calm and to be able to prioritize between emergencies such

as managing injured persons and containing the fire. Finally, situation awareness was mentioned in the form of risk awareness by several interviewees as being a skill that crew must obtain through fire safety training. Crew should therefore be able to (1) identify potential fire hazards, (2) identify the nature of the fire hazard (electric, chemical, toxic etc.) and (3) take appropriate measures to prevent or minimize the risk. Especially important when it comes to fire risk awareness onboard is also the existence of fire patrols, which was mentioned by interviewees with working experience from Ro-Pax vessels. Individuals being part of fire patrols are therefore trained in order to be able to identify potential fire hazards onboard and take appropriate measures to minimize or prevent fire risks.

Social Skills
Leadership
Communication
Teamwork
Crowd Management
Stress Management

Table 4. *Social Skills*

6.2 Fire Safety Training Conducted Onboard and the Impacting Factors

6.2.1 Fire Safety Training Onboard in Relation to Rules and Regulations

In this study, a gap was identified between how fire drills are normally conducted onboard and the requirements according to SOLAS and the ISM Code. Even though it appears that fire drills are not postponed, but always carried out, due to different factors, the drills do not always contain all the components and elements required according to the Regulations. The factors identified as the most influential are intangible factors such as *leadership* and *safety culture*. It can be stated that there is not one factor alone that determines how the drills are conducted, as many of the factors are intertwined and work coherently. However, as the fire drills should be conducted according to the relevant Rules and Regulations, it is relevant to consider this interrelation.

According to SOLAS, cargo ships shall conduct a fire drill once every month and onboard passenger ships once every week. It is suggested, however, by some of the previous research that drills are at times postponed or not carried out. Based on this study that does not seem to be true regarding fire drills. None of the interviewees have experienced that a fire drill has been postponed or not been conducted onboard. The fire drills are always carried out according to the *frequency* stipulated by the regulations and the company's procedures. However, there is an indication among the crew onboard that at times it is hard to solve the equation of a smaller crew, commercial interest, short sea voyages and rest hours and the fact that good fire drills take time to plan and to conduct. The drills are in these cases not postponed or cancelled, but the drills are kept short and lack certain elements required according to SOLAS.

The officers onboard state that fire drills on occasions are *theoretical* and therefore the practical elements required by SOLAS are not carried out. According to the interviewees a theoretical fire drill involves the demonstration of equipment, and not the practical use of it, or the presentation of a video covering fire safety or fire prevention which is followed up by a reflective learning session. These theoretical fire drills, however, are not considered to be a fire drill according to the requirements under SOLAS. They are, as stated by an officer, a great complement to the fire drills for the fire safety training of the crew onboard, but they cannot be considered or recorded as a fire drill.

SOLAS requires further that the fire drills should include certain practical elements and a *realistic scenario*. The realistic scenario is also emphasized by previous research as an important component in fire safety training and for improving the emergency preparedness of the crew. Furthermore, the officers and shore employees in this study also believe that the fire drills carried out onboard should be realistic, as realistic drills create an engagement among the participants and improve the crew's emergency preparedness. However, based on the data from this study not all fire drills conducted contain a realistic scenario. Both the officers onboard and the shore employees state that drills at times only contain the components of mustering, the smoke divers putting on their gear and pressurizing fire hoses on deck.

In addition, a *gap* is identified between how the officers and shore employees believe that the fire safety training should be conducted and how it is conducted in reality. How fire safety training should be conducted and what should include according to the interviewees does not always correlate with how fire drills are conducted in reality. The interviewees believe that, among other things, the scenario of the fire drills should be as realistic as possible, involve practical elements and physical use of equipment, that roles of the crewmembers should be changed occasionally and that a debriefing must be held after each fire drill. The officers onboard witness and say that the fire drills often lack one or more of these components at times, a view which is shared by the shore employees that believe that fire drills only occasionally are conducted as they should be.

The officers onboard and the shore employees in this research believe that there are other aspects, except from fire drills, that are important in relation to fire safety training. Reflective learning sessions or minor training sessions with a small number of crewmembers are mentioned by the interviewees as additional fire safety training. It is emphasized by an officer onboard that even though SOLAS requires that the fire drills must be carried out once every month, that requirement does not prevent the crew from performing *additional training*. One shore employee stated that:

> *"… today we focus so much on the big fire drills where you involve every part. I think you should make maybe small drills with the firefighting team or other parts more often so that you build your organization."* (HSE Superintendent)

However, none of the officers have any experience from additional fire safety training or drills onboard. This can be attributed to the lack of time mentioned by the officers onboard. As the time for conducting fire drills is limited, the time for conducting additional training is as well. The focus is then put on complying with the SOLAS requirement regarding the frequency of drills. A few of the interviewees indicate that this might not be the most effective or efficient way of improving the crew's fire emergency preparedness.

The requirements stipulated by SOLAS ensures, through the verification of audits and inspections, that fire drills are performed onboard. However, the highest level of safety culture is referred to by the interviewees as performing drills for your own safety, and not because SOLAS requires it. This statement is in line with previous research that suggests that inadequate fire drills are not an issue of insufficient regulations, but rather the incomplete implementation (Tac, Akyuz & Celik, 2020) of existing regulations at an operational level. The data from this study indicates that the Rules and Regulations do not seem to be the factor which affects the quality of the drills the most. Both the officers and the shore employees in this study believe that SOLAS sets an adequate level for the fire drills. The identified gap and the quality of the fire drills can therefore be attributed to other more influential factors than Rules and Regulations.

6.2.2 Defining Lessons Learned and Their Impact on Fire Safety Training

This study indicates that there is a lack of effective evaluation of the fire drills carried out onboard. There is first of all a failure to identify *lessons learned* after each fire drill. Even though several officers onboard and shore employees believe that the *debriefing* is one of the most important components of a fire drill, there is often not a formal or effective debriefing carried out after each fire drill. Furthermore, lessons learned, and improvement areas identified in the reports are not effectively used to evaluate and improve the emergency preparedness of the crew as they are not incorporated into the next fire drill carried out.

According to the ISM Code, there shall be a debriefing after each drill or exercise to evaluate the drill or exercise. The purpose of the debriefing is to gain feedback and to assess the crew's capabilities and the effectiveness of the emergency procedures, which is an important part of identifying the training needs. Two of the interviewees stated that "*these things cannot always be perfect, then we don't need to train*" and that it is a key component to have a debriefing so "*you can make good lessons learned and real lessons learned*".

> *"I think also the most important component is that it is okay to do something wrong during a drill, that you can be quite frank and tell your teammates that actually I don't know how to do this. Because it's a big pressure on someone being part of these firefighting teams and pressure to know it all, but nobody knows it all and all you need to know is how to ask."* (Safety Controller)

The *debriefing* is emphasized by the officers onboard as an opportunity for the crew to ask questions and discuss the drill and fire safety and fire prevention in general. It is considered important to have these debriefings in order to improve and for the crew to learn and develop. As stated by an officer, they must be conducted regularly as the longer that someone has been onboard the less likely they are to raise a question or admit that they are unfamiliar with a certain task. According to the data from this study, the debriefing is an important part of identifying the lessons learned and furthermore evaluating the crew's emergency preparedness.

The lessons learned shall according to the ISM Code be addressed in the SMS. The interviewees working within the tanker segment stated that lessons learned are addressed in a *"drill evaluation report"* which is written for all drills conducted onboard. The report consists of a description of the drill carried out and the lessons learned during it. As there is not a debriefing carried out after each fire drill, the lessons learned in these reports are according to a shore employee very general. The officers onboard in general considered this report as an administrative task that has to be done after each drill and several officers do not see any value in writing the report other than having it as evidence that the drill has been conducted in a certain manner. Two officers stated that the reports are *"a necessity"* and have the purpose of making it *"more difficult to fake your drills".*

This attitude from the officers towards the reports can be transferred to the opinion of the interviewees within the shore management or experience from working within the shore management. These interviewees believe, based on reading the reports, that there is a general lack of incorporating the lessons learned into the next drill. They see that identified improvement areas are not taken into account during the next fire drill, or that the same improvement area reoccurs several fire drills consecutively without any action taken to improve.

6.2.3 The Impact of Leadership on Fire Safety Training

The majority of the officers and shore employees in this study argue that how the fire drills are conducted and their content depends on the *'drill leader'*, which is the person planning and leading the drill. Normally it is the same person planning the fire drills on each occasion, which would be an officer with this responsibility assigned to their rank. The content of the fire drills and their quality is according to the officers in this study largely dependent on this person's attitude, interest and competence.

> *"If you don't have dedicated leaders for example, you will not have good performed drills in general because everybody follows the leader and especially when it comes to drills. There is not one AB for example that stands up against the whole crew and says that 'ah we need to practice more about this, and we need to put more focus'. But it must come from the top and it goes all the way down. If your leadership thinks that the drills and training is important and can motivate that one, then you will also get*

the other people involved. The other people are maybe just waiting for a signal to be involved because they also have a lot of experience from things that they have seen in other places and so on. But you need to get involvement from everyone. [...] Of course in an ideal world everybody is involved but that is not the case so. But you need persons in charge that are dedicated." (HSE Superintendent)

The above statement by an interviewee summarizes the importance of not only the drill leader, but *all leaders* onboard. Furthermore, it emphasizes just as previous research has indicated, that it is the responsibility of the Master and shore management to ensure that the drills carried out onboard fulfil the requirements and have a certain level of quality (Oltedal & McArthur, 2011). Therefore, the leaders' engagement and dedication to perform high quality drills and to improve the emergency preparedness of the crew have a large impact on the effectiveness of the training and essentially the firefighting organization onboard. The officers onboard emphasize that the senior officers' interest and engagement when participating in the drills increase the quality of the drills conducted.

The importance of the leaders as in senior officers and management and their engagement is emphasized by several interviewees, especially among those working onboard the ships. A few of the officers in this study perceive that how the drills are conducted are much left up to the officers onboard. The *shore management* often provides neither guidance in the company's procedures on how to plan and conduct fire drills, nor gives feedback on drill evaluation reports written in order to ensure that the crew improves. The data from this study indicates there is often a lack of engagement from the shore management in how the fire safety training is conducted onboard.

"Many times onboard the ship we get new procedures, new regulations and it is up to us to implement them basically. Taking a bigger part of this would be one thing and taking every safety aspect in the same consideration because what is important for the crew is maybe not as important for land-based organization. But to actually get to a higher level you have to take all factors into consideration. To show what the crew think is important to give some weight to that would maybe get the crew more interested in the aspects that are important for the land-based organization." (Master)

That fire drills fulfil the requirements and are properly evaluated is the responsibility of the shore management, not just the senior management onboard. Therefore, the potential lack of procedures, guidance and feedback from the shore management to the officers onboard may have a negative effect on the drills onboard. The engagement of the shore management is emphasized by some of the officers onboard. Even though, as stated by a shore employee, the shore management cannot be *"there holding their hands making sure that they follow the requirements"*, the shore management has a supporting role to fulfil. The introduction of guidelines and procedures to the crew and officers on how to conduct drills is a part of this

support. However, so is ensuring that the officers onboard have the time and the resources fulfil the requirements. Just as the senior officers onboard, the shore management must show that safety and safety training is important and lead by example.

6.2.4 The Impact of Safety Culture on Fire Safety Training

According to previous research, the safety culture has a large impact for the emergency preparedness of the crew. Based on the statements by the interviewees in this study, safety culture seems to have a large impact on the fire safety training onboard, and especially the drills. How drills are prioritized, planned and conducted are according to the interviewees dependent on the interest, attitude and knowledge of the person planning and leading the drill. Overall, the emergency preparedness is dependent on factors such as *attitude and motivation* (Vinnem, 2011) and effective fire safety training provides that the participants are engaged, understands its importance (Vukonić, Bielić & Russo, 2016) and are positive towards the training (Wu, Jin & Fu, 2014). The quality of the drill is therefore also dependent on the attitude of the crewmembers participating in the drill and not only the person planning and leading it.

As stated by many of the interviewees, if there is a lack of safety culture fire drills are not taken seriously and are regarded as something that just has to be done. One officer said that conducting fire drills is more or less a routine onboard, and therefore the engagement, attitude and interest in the fire drills is low. The attitude and interest of the crew are mentioned by the interviewees as components that affect the quality of the training conducted and how fire drills are perceived by the crew onboard.

> *"I think that it is important for [the crew] to be included when planning and executing the drills so they actually gain something and learn something. Because if they don't then there will be a lack of interest. It is a part of the safety culture actually."* (Master)

Other officers emphasize the importance of planning and conducting drills that create *engagement* among the crew, and the crew must be involved in planning the drills to achieve the interest and engagement. One shore employee stated that in order to perform good fire drills onboard the sense among the crew that they are working towards a *common goal* is important. If the drills are appreciated by the crew and they feel an engagement, the drills will per se not become better. However, working onboard a vessel with a sound safety culture and a crew which feels as a team and are motivated will together plan and conduct drills that are improving their skills towards a common goal. That all crewmembers are actively involved and participating in drills is important for having an effective emergency preparedness onboard. This is especially the case, as stated by a few officers, when the number of crew members onboard, the vessels are decreasing, and everyone onboard has an important role to fulfil.

It can be suggested further that the safety culture onboard also affects the *quality of the evaluation* of fire drills. The interviewees describe safety culture as the "atmosphere" onboard,

the crew's attitude and behaviour, and that everyone onboard regardless of rank has the ability to speak up, ask questions and question actions.

> *"In a good safety culture anyone can come to the fire chief to tell them that there is something they can improve."* (DPA)

The officers believe that especially the ability to speak up and raise questions affects the quality of the debriefing after a fire drill. The *debriefings* are an important tool in identifying lessons learned and improvement areas which are essential to the effective evaluation of the drills, and therefore it is important that all officers and crew actively participate. If the safety culture is absent or if the atmosphere onboard does not allow open discussions between the crew and the officers, the quality of the debriefings will reflect this culture.

> *"If you involve them in the debrief and let them describe what happened and how they, what they thought about their actions or whatever, I think then they tell."* (HSE Superintendent)

The above statement by a shore employee emphasizes the importance of *inclusiveness* and *openness* during the debriefings. The officers onboard believe that it is important that the crew, and especially the officers, are open to others' opinions and suggestions. One officer said that it is preferable that the crew tell what they thought of the drill instead of the drill leader, but in order for this to be successful there must be an openness and a good safety culture.

Furthermore, the safety culture may also affect how the evaluation of fire drills is perceived by the officers onboard. The officers onboard seem to be of the idea that the *drill evaluation reports* are a necessary administrative task, which must be completed after each drill. A few of the officers stated that the shore management seldom provides any feedback on the reports sent to them. As stated by an officer, if there is a sound safety culture within the company the shore management wants the crew onboard to improve and therefore provides feedback on the drill evaluation reports. According to the experiences of this officer, in companies where the safety culture has been low, the shore management only verifies that the drill described in the report complies with the regulations.

6.2.5 The Impact of Audits and Inspections on Fire Safety Training

Besides the evaluation of the drills and the emergency preparedness procedures that is done by the crew themselves, fire drills and fire safety training are also evaluated or verified by external parties. Ships and its crew are subject to a number of inspections, such as internal and external audits stipulated by the ISM Code, port state controls and within the tanker industry the vetting inspections[1]. The purpose of these inspections is to verify that the ships and their management

[1] A vetting inspection goes under the Ship Inspection Report Programme (SIRE) developed by OCIMF (Oil Companies International Marine Forum) in 1993 to address sub-standard tanker shipping. A vetting

fulfil a certain level of safety onboard and that they comply with applicable rules and regulations.

In general, the interviewees believe that *audits and inspections* fulfil an important aspect of keeping a high level of maintenance and safety onboard. It provides a second set of eyes and forces the crew and officers onboard to ensure that the vessel is in good condition, that records are in order and that the crew and officers are updated on regulations and procedures. However, some interviewees believe that the value that the audit has for the crew and the fire safety training is dependent on the *inspector or auditor*. In relation to performing drills during an audit or inspection an officer stated:

> *"I think of course it is good, but it requires that the person who is auditing actually has more experience from prior training and I am not sure who that would be. It would require someone who is much more experienced with fires than we are onboard for it to be... [...] If someone from the HSE department would come onboard to see a drill, he would only evaluate how we do the drill according to the regulations."* (Chief Officer)

The interviewees have experienced that both port state controls and external audits have asked the crew to perform a fire drill during the inspection. However, these inspections do not evaluate the drill held per se, but rather check that the crew know where to go and what to do in the event of a fire onboard. The focus is on evaluating the emergency preparedness of the crew rather than the actual fire drill. They normally do not provide constructive feedback on how the drill was conducted, but if something was not up to standard during the drill it is reflected in the report of the inspection or even generates an observation or non-conformity.

Even though some interviewees have experienced performing fire drills during an inspection or audit, it is not required by the crew to conduct a fire drill at every audit or inspection. When verifying the compliance regarding drills, the inspector and auditor most often look at the *drill evaluation reports*. The inspectors verify that the fire drills are conducted with the frequency and requirements stipulated in SOLAS and the company's procedures. According to the officers onboard it is therefore important that the report contains all elements required by SOLAS as the report is used as evidence for the drills being conducted according to SOLAS and the company's SMS. This indicates that the report written might not reflect the actual drill carried out. One officer stated that especially vetting inspections are more focused on "*how well documented everything is rather than how it is in reality unfortunately*".

The audits and inspections do not seem to have a large effect on the improvement of fire safety training onboard or the crew's emergency preparedness. The effect that the audits and inspection seem to have based on this study is the *compliance-driven completion of drill*

inspection follows a standardized questionnaire and focuses on quality and safety standards. The reports from the inspections are used as a risk assessment tool to value tanker shipping companies and their vessels (OCIMF, 2021).

evaluation reports. As the auditor or inspector checks this report to ensure that the drills fulfil a certain standard and are carried out as per the required frequency, the focus among the officers is to ensure that the drill described in the report complies with the regulations and procedures. The focus, or the purpose, of writing the report is not as per the ISM Code to evaluate the drill in order to improve the emergency preparedness of the crew. Therefore, it can be suggested that the audits and inspections do not affect the fire safety training per se, but act towards a compliance-driven evaluation of the fire drills onboard. However, it must be mentioned that the officer and shore employees in this study emphasize the importance of the audits and inspection for the safety culture onboard, which in turn affects the fire safety training positively.

6.2.6 The Impact of Crew and Officers' Knowledge on Fire Safety Training

The knowledge of the crew and officers onboard is reflected on how fire drills are carried out. A crew that is knowledgeable about the requirements, plans and conducts the drills accordingly, assuming that the culture onboard perceives compliance with the regulations as important. The interviewees believe that it is important that officers are knowledgeable about the regulations in SOLAS as they are responsible for planning and executing the drills. This relates to the officer's overall responsibility for the quality of the training onboard as they are planning and leading the drills.

The quality of the drills is according to the interviewees highly dependent on the officer planning the drill and therefore the knowledge of said officer. The knowledge of the requirements in SOLAS and the ISM Code is therefore a prerequisite for planning and executing fire drills that comply with the regulations. How knowledgeable the crew and officers are of the SOLAS requirements and the procedures in the SMS, is according to the interviewees dependent on the safety culture onboard, the personal interest and attitude, or on their shore-based training. The lack of knowledge of the procedures and requirements may have a negative effect on the fire safety training onboard. Some interviewees are of the opinion that it is important that both the officers and the crew are knowledgeable about the requirements. These interviewees argue that the more aware the crew is of the requirements, the more noncompliant drills can be avoided.

> *"For the ratings I think basic understanding is good to have so they know what is expected from them [...] Of course if you know about things the safer you act and the better you can be prepared, but basic understanding. That also gives them information about what they can expect from a ship organization [...] Normally we are happily ignorant because we don't know so much and think everything is okay, but the more we learn the more we realize how little we know and what to improve."* (HSE Superintendent)

When drills are regarded as something that has to be done or a routine, it is an indication that the crew and officers are unaware of why drills are conducted and the purpose of repeating the

same task on a weekly or monthly basis. The more knowledge the crew and officers onboard have, the more they know what to improve and how to improve. A crew that is knowledgeable about, for example, how skills are developed and retained overtime will understand the importance of performing more or less the same drill with the same persons on a regular basis.

Based on the data in this study, it is indicated that in relation to fire safety training and planning good fire drills, the officers onboard do not perceive knowledge of rules and regulations as the most important knowledge. One of the interviewees with personal experience from a fire onboard a ship, believes that the reason for drills being conducted without realistic scenarios is *"because as you have never experienced a fire you don't really know what you should train on"*. This is further emphasized by other officers who believe that it is important that the training ashore includes extinguishing fires and smoke diving in compartments on fire. This training creates an understanding of what a real fire is like in terms of heat, reduced sight and smoke. When planning and executing drills this knowledge is essential as a complement to the mandatory requirements in order to create a realistic scenario.

The knowledge of the crew and officers is reflected also in the evaluation of the drills. A crew which is knowledgeable about the purpose of writing the drill evaluation report and its importance for the emergency preparedness of the crew is more likely to complete value-adding reports. The officers that are knowledgeable of the report's purpose will furthermore understand the importance of utilizing the report for planning upcoming drills. In relation to the evaluation of drills it is also important that the crew and officers are knowledgeable of what is required by the firefighting organization onboard in order to identify the improvement areas.

7. Discussions

7.1 Methodology Discussion

In relation to the choice of *combining literature review and interviews* for the qualitative data collection, it can be suggested that said combination was highly compatible with the research objectives of this thesis. That said, the literature review of the relevant articles and bibliography, as well as the review of the applicable rules and regulations provided a solid foundation for understanding the framework behind fire safety and fire safety training onboard. Following that, the choice of interviews to obtain primary qualitative data was suitable for giving to the researchers a clear view of the practices onboard in relation to fire safety training and fire drills. Conducting interviews was a rewarding experience, as it provided the researchers with the opportunity to explore in detail the identified areas of interest and to interact face-to-face with the interviewees. The duration of the interviews, varying from 40 minutes to one hour each, provided sufficient time to obtain data in order to answer the interview questions, as well as, to ask follow-up questions and clarifications.

In terms of *reliability*, while the researchers consider that conducting interviews with individuals from the shipping industry in conjunction with the data obtained from the literature review was sufficient to provide answers to the research questions, some limitations do exist. That said, the interviewees were limited in terms of numbers to 12 interviewees, all working within Swedish registered companies either in the tanker or Ro-Ro/Ro-Pax sector. Furthermore, all the interviewees working onboard were officers and the interviewees working ashore have positions such as; DPA, Safety Controller, HSE Superintendent and Safety and Security Superintendent. Therefore, while the results can be considered reliable within the scope of this thesis, the various limitations should be taken into account in relation to the reliability of the results on a more general basis.

The interviewees in this study were contacted through the personnel network of the researchers. As the interviewee and the researchers in some cases were known to each other and the researchers were, despite not disclosed during the interviews, familiar with their current employer, there was a risk for biased answers in relation to questions on for example compliance with regulations. However, the interviewees were encouraged to speak freely and were informed of their anonymity with the study. As the interviewees for example expressed criticisms towards shore management, company procedures and how drills are conducted onboard, it is considered that the interviewees spoke freely without being affected by being familiar with the researchers.

In addition, even though the interview method was a highly rewarding experience and offered rich data, it also had some challenges. The first challenge was in relation to finding and approaching the most suitable individuals for the interviews. Even though the researchers received mostly positive replies from the majority of the interviewees that were approached, they were also faced with another challenge, being the receipt of negative replies or the lack of replies. One more challenge that should be considered as relevant is that the interviews were

conducted during the Covid-19 pandemic, thus it can be suggested that additional workload might have been one the reasons for receiving negative replies from prospective interviewees. The impact of the Covid-19 pandemic and the requirements for social distancing required for the interviews to be conducted online using Microsoft Teams. Using online tools for conducting interviews also resulted in some limitations. It can be mentioned that a small percentage of the interviewees did not have their camera open during the interview, therefore, the interviewers were not able to observe facial expressions and gestures as complementary features in understanding the interviewees' point of view and argumentations.

However, despite the minor limitations and challenges of conducting the interviews online it was still considered as the most appropriate method. Based on the objective of the study, a qualitative study was preferred in order to answer the research questions. Even though a qualitative study can be conducted using questionnaires, the use of interviews provides more in-depth answers and allows the researchers to ask follow-up questions. The limitations of using online interviews, and the risk of interviewees not wanting to be recorded with video and therefore not seeing the interviewee's body language, it is still more beneficial to have the interviewees describing a fire drill verbally than in written text. Despite the risk of missing the facial expressions or body language of an interviewee, the interview as a method still provides more elaborated answers than questionnaires.

Some issues were also identified, in relation to the *interview questions*. First of all, it can be suggested that some of the questions chosen for the interviews might have been considered as leading in some cases. An example of such a leading question would be when the interviewees were being asked '*How useful or important do you consider that the reporting of incidents involving fire onboard is and why?*'. This type of question suggests that the reporting of incidents is indeed considered to be important or useful and therefore all interviewees instinctively replied positively to this question. Furthermore, some of the questions asked produced a one-word 'yes' or 'no' answer, which required additional follow up questions by the researchers. An example of such a question would be '*Is there a debriefing after every fire drill?*', which often produced a yes or no reply, that required further questions and further elaboration. Other interview questions, such as '*What do you believe is the most important learning that can be gained from a fire drill?*' were considered unnecessary and were subsequently dropped due to the existence of a similar interview question, being '*What do you believe is the most important component of a fire drill that must be trained / practised during the drill?*'. That was because the majority of the interviews had already answered what the most important learning would be, when answering about the most important component. Therefore, these two terms were often considered as similar or used interchangeably by the interviewees, thus making the existence of two interview questions about this subject unnecessary. It can therefore be suggested that the interview questions should have been formally reviewed and updated after a couple of interviews based on their usefulness and functionality. However, the researchers made individual adjustments during each interview by

asking tailored follow up questions in relation to identified areas of interest and in accordance with the experience and expertise of each interviewee.

7.2 Suggestions and Discussion

7.2.1 Discussion

7.2.1.1 What skills concerning fire safety training are considered important?

In relation to the first research questions, being '*What skills concerning fire safety training are considered important?*', the findings of this research indicate that different sets of skills, such as *Practical skills*, *Theoretical skills* and *Social skills* are considered important. While an initial categorization and classification of skills may be useful in order to create a structure and organize the data obtained through this research, the identified skills are interrelated and intertwined. With this in mind, it can be discussed whether obtaining practical skills, required under SOLAS, through fire safety training, without a basic foundation of theoretical skills, would be sufficient for the crew to respond successfully to a fire onboard. Even though having theoretical knowledge may not be required when dealing with an actual fire onboard, it can be argued that the necessity for officers onboard to have theoretical knowledge about SOLAS and the ISM Code may have an impact in relation to compliance, but also in relation to the quality and content of fire safety training. That said, knowing the requirements under the relevant regulations and company procedures, may enable officers onboard to design more suitable fire drills that cover all the necessary aspects regulated in SOLAS and the ISM Code.

The same logic may apply in arguing that obtaining the practical skills required under SOLAS without the development of social skills, may result in a crew that is individually skilled, but cannot work well within a team when an emergency situation, such as fire onboard, takes place. Therefore, obtaining practical skills without developing social skills, such as communication skills and teamwork, may result in miscommunication, lack of trust and individualistic attitudes and behaviour onboard. In the promotion of team spirit onboard, the participation in fire drills and the existence of engaged leaders can also play a massive role. Therefore, the authors argue that having crew members onboard that have acquired, through fire safety training, practical, theoretical and social skills may not be enough without an engaged and skilled leadership and management both onboard and ashore. That is because, the engagement of the management is essential in establishing the objectives, in providing motivation and guidance to the crew, while at the same time being able to hold individuals accountable and exercise authority. That said, the importance of social skills has also been recognised within Regulations, such as the STCW Convention (the 'Manila Amendments'), and in previous research, such as the one conducted by Fjeld et. al (2018). According to Fjeld et.al (2018), *Non-Technical Skills*, such as communication, leadership, work-load management, decision-making and situation awareness, were identified and should be combined with Technical Skills.

Based on the above, it can be suggested that a *combination* of the above skills is required, however, obtaining and maintaining these skills should be viewed as a continuous process. That is also important considering the rapid development of technology, the digitalization and

automation of the industry and the introduction of new technology onboard, such as renewable energy and new fuels, for sustainable development. These technological developments in shipping will require a simultaneous parallel and constant development of the relevant skills that crew onboard should possess. Therefore, from a *sustainability lens*, one may argue that some of the most important skills that crew should obtain through fire safety training are related, not only to practical skills according to SOLAS, but also social skills. These may primarily be in relation to *adaptability* and *problem-solving* skills. Therefore, the crew should be able to adapt fast and develop new skills in order to handle the rapid changes in technology and use of renewable energy sources, such as electric, solar and wind power. In this direction, one may argue that the slow production of relevant Rules and Regulations might result in training gaps when it comes to new technology. Even though regulations, such as the STCW Convention, have been amended several times in an effort to keep up with technological developments, implementation is often slow. Therefore, shipping companies striving towards sustainable development, should consider additional training for their crew to be able to obtain, maintain and develop the necessary skills for the use of new technology onboard.

7.2.1.2 What factors have an impact on fire safety training onboard?

The second research question, "*What factors have an impact on fire safety training onboard?"*, had the purpose to determine which factors have an impact on the fire drills conducted and the effect of them. It was identified that the fire drills onboard are affected foremost by the *Leadership*, *Safety Culture* and the *Knowledge* of the officers and crew, and these factors all correlate and are dependent on each other. How the drills are conducted onboard is dependent on the overall safety culture and the drill leader's interest and knowledge. Therefore, the leadership onboard determines the safety culture, and the safety culture determines the level of knowledge the crew and officers possess and vice versa.

The assumption made based on previous research that the level of the *Safety Culture* onboard is reflected in how fire drills are conducted and prioritized seems to be true. Based on the data from this study, it can be suggested that the Safety Culture and Leadership onboard override other factors, such as lack of time or workload, which according to previous research (Tac, Akyuz & Celik, 2020; Oltedal & McArthur, 2011) affect emergency preparedness training to a high extent. In this study, none of the interviewees had experienced that fire drills have been disregarded or postponed, as suggested by previous literature. The fire drills are carried out, but some officers stated that drills occasionally are kept short or lack certain elements due to the lack of time. Despite this, the lack of time is not the most prominent factor in the data from this study. If there is an absence or lack of Safety Culture onboard, drills are regarded as something that has to be done, and the importance of conducting the drills is not understood and it is therefore not prioritized when there is a lack of time or high workload.

Rules and Regulations, and the verification of them through audits and inspections have an effect on the drills carried out. However, their effect is not as apparent as the other factors and it is neither solely positive or negative. This correlates to previous research (Størkersen,

Antonsen & Kongsvik, 2017) on Rules and the Safety Culture onboard which argues that the implementation of Rules and Regulations does not necessarily increase the safety onboard. SOLAS and the ISM Code set the requirement to conduct fire drills and establish procedures for fire safety training and emergency preparedness. If the requirements had not been in place, fire drills would not be conducted unless there was a sound and properly functioning safety culture both onboard and within the Company. In a good Safety Culture conducting fire drills is not compliance-driven but driven by an understanding of its importance for the crew's emergency preparedness.

Bye and Aalberg (2020) among others (Kongsvik, Størkersen & Antonsen, 2014; Fenstad, Dahl & Kongsvik, 2016) argue that the emergency preparedness procedures and the regular safety training are parts of the SMS which are appreciated by the crew onboard, while its implementation also contributed to an increased administrative workload (Størkersen, Antonsen & Kongsvik, 2017). The *evaluation* of fire drills was introduced with the implementation of the ISM Code, while conducting fire drills has been a requirement according to SOLAS since 1974. Based on the results from this study, conducting fire drills seems to be a subconscious act and a natural part of life onboard, just as any other task. The majority of the interviewees in this study believe that it is important to conduct the fire drills, but not from a pure compliance perspective. Even though the fire drills per se are regarded as both necessary and beneficial for the crew onboard, the results from this study indicate that evaluation of the fire drills is compliance-driven and not fully implemented. The evaluation reports are regarded as a purely administrative task and its purpose is to have evidence of the drills conducted during inspections and audits. However, evaluating the drill has the purpose of evaluating the emergency preparedness of the crew and not whether it complied with SOLAS or not.

The *Regulations* set a mandatory requirement to conduct fire drills that contain a certain number of elements, and therefore the drills are conducted, or reported to be conducted, accordingly. The question is if performing fire drills according to a predefined structure fulfils its purpose of evaluating and improving the emergency preparedness of the crew. Many of the skills considered important are non-technical and performing predefined drills to comply with mandatory requirements might not be the most effective way to obtain those skills. The requirement of conducting fire drills may have created a focus on fulfilling this requirement and removing the focus from other aspects of fire safety training. Therefore, a fire drill which does not include all the components required, can still be considered as good fire safety training and improve the crew's emergency preparedness. Finally, a fire drill which evaluates the emergency preparedness of the crew and officers does not necessarily have to contain all items in a predefined list, as long as it covers key aspects.

7.2.2 Suggestions in Relation to Skills

7.2.2.1 Expansion of Practical Skills

The most important *practical skills* that were mentioned by all interviewees are relating to the use and functionality of the equipment and systems onboard. However, the interview data

suggests that there is often a lack of using pressurized hoses, of using ventilation control and of training in the use of fire doors in fire drills conducted onboard. Based on the applicable provisions under SOLAS, it is considered important for the fire safety training to expand in order to include the above and for the practical skills of the crew to be extended to cover these aspects. That said, it can be suggested that training with *pressurized hoses* should be included more often in fire drills conducted onboard in order for the crew to become familiar with the difference in *weight*. That is because pressurized hoses are much heavier and restrictive in their use and training in their use and functionality is essential to ensure their proper use in case of a fire onboard. The same applies also in relation to including training about *ventilation control* and the use of *fire doors* in fire drills conducted onboard. Both aspects are considered of importance in case of a fire onboard and should be included in fire drills under the relevant requirements in the SOLAS Convention, but particular emphasis should be given in the use of fire doors. Obtaining skills for the correct use of *fire doors* is particularly important as fire doors are a part of the *fire protection system* onboard and can reduce the spread of fire and smoke between different areas and compartments onboard, by containing it to a specific area for a longer period. Therefore, fire safety training and fire drills should regularly include the use of fire doors, in order for the crew to be able to operate them properly and to check their proper maintenance and functionality. The above practical aspects should be included more often in fire drills also in order to ensure compliance with the applicable requirements under SOLAS and the ISM Code and to enable the crew to acquire the relevant skills.

Furthermore, even though the majority of the interviewees confirmed that testing of *communication equipment* is a part of the fire drills, most of them had repeatedly experienced issues with its proper use. It can therefore be suggested that particular emphasis on the proper use and functionality of the communication equipment should be given during every fire drill and a thorough training should be given to all crew members onboard in relation to how to use the equipment correctly. This would include aspects such as which *frequency* to use for communicating and how to use correctly the radio and microphones. Based on the interview data, it appears that there is also a deficiency identified in relation to the proper use of the *fireman's outfit and gear*, as the *speed* of gearing up is often, but not always timed during a fire drill. Considering that when a fire starts onboard, time is of the essence, it can be stated that the crew should practice the speed of gearing up during the drills by being timed. That is due to the importance of saving time in case of an emergency onboard and during fire drills the crew should also make sure of choosing the correct size of outfit and gear. It was suggested further that the crew may not always pick the right *size* of outfit or gear, such as protective boots and helmets, during fire drills. This aspect should also be considered by the crew, as having incorrect size of gear or footwear could potentially lead to personal injuries or other accidents onboard. Another interview suggested further that basic practical skills, such as putting on the outfit and gear and testing and using the communication equipment should be also practiced as *separate shorter drills*. During these specialised drills, emphasis will be given to this specific task and this may ensure that the crew is indeed familiar with the use of the outfit and gear and will have sufficient time to focus, practice and ask questions.

It is also important for the crew to obtain *ship-specific knowledge*, such as the location of muster stations, alarm button and fixed firefighting equipment and be acquainted with the applicable *ship-specific procedures* and *high-risk areas* onboard when it comes to fire hazards. These aspects should therefore be always included in the fire drills and the senior officers should be available to introduce all relevant ship-specific procedures to new crew joining onboard. Finally, the crew should also obtain *cargo-specific knowledge* in relation to the most typical cargoes carried onboard, in relation to *dangerous cargoes* (explosive, toxic or flammable) and *chemicals*, as well as, in relation to fire risks associated with the carriage of *reefer trailers* onboard Ro-Pax vessels. This knowledge appeared to be important for most of the interviewees, however, the data suggested that this does not always form part of their training. Therefore, it can be suggested that the Master and/or senior officers onboard should regularly inform all the crew about the cargo carried onboard and about the most common fire risks in relation to that particular cargo. A detailed list of the *location* and *properties* of different cargo carried onboard should be given, as well as *instructions* about loading, stowing and discharging said cargo. The *scenarios* of the fire drills can also be adjusted for the relevant periods when particular cargoes that are prone to fire risks are carried onboard, in order to include fire training with this type of cargo. An example of that may be the use of chemical suits during a fire drill when the scenario includes the extinguishing of a potential fire on chemicals carried onboard.

7.2.2.2 Establishment of Theoretical Skills

Other sets of skills that crew should obtain through fire safety training are *theoretical skills*, relating to fire theory, risk awareness, risk assessment and knowledge about rules and regulations. However, it can be discussed whether or not lower rating crew should be required to obtain only a basic level of theoretical skills in order to understand the purpose of their tasks and follow instructions. In relation to this, several interviewees stated that lower ranks are probably not well aware of the applicable Rules and Regulations and may possibly not possess a sufficient basic understanding of the framework. On the other hand, the interviewees suggested that the Master and officers onboard should be equipped with a high level of theoretical skills, as their tasks are often connected to creating and implementing processes and procedures that need to comply with the relevant rules and regulations. They should also be equipped with a higher level of risk awareness and be able to assess risk and act accordingly.

Some suggested methods for obtaining such skills are the use of *video-learning* and of movies, the participation in *theoretical drills*, as well as, the creation of *safety bulletins*, the use of *safety toolbox talks* and the utilization of *lessons-learned* from previous incidents. That said, it can be suggested that the shore management personnel should focus on preparing and sharing safety bulletins to the vessels on a regular basis, based on lessons learned from previous incidents. Safety bulletins can also inform the crew about potential changes or updates in the applicable Rules and Regulations and draw their attention to important provisions that they should be aware of. The fire drill leaders should also make sure that there is a balanced rotation

between practical and theoretical fire drills to ensure the provision of a holistic training of the crew onboard. Theoretical fire drills should include fire theory and video-learning may be used to cultivate skills relevant to risk assessment and risk awareness onboard. During *briefing or debriefing* sessions before or after fire drills lessons learned should also be included, and the Master or officers onboard can provide insight relating to rules, regulations and company procedures. The above may contribute to the establishment of a basic foundation of theoretical skills for all the crew and influence positively the understanding and performance of their tasks.

7.2.2.3 Development of Social Skills

Of equal importance is also for the crew to obtain and develop *social skills* through fire safety training, such as communication, teamwork, leadership, stress management and crowd management. However, while skills such as communication and teamwork are relevant and necessary for all crew to obtain, other skills, such as leadership may be relevant only for officers and for the Master. In terms of method, *fire drills* appear to be the most suitable way for the crew to practice collaboration, teamwork and communication and emphasis should be given to the use of language and communication flow both internally and externally. The fire drill leaders should also make sure that the entire crew participates in fire drills and that everyone is actively involved and having clear roles and responsibilities. In relation to *leadership and teamwork*, the officers onboard should also train in accordance with the requirements under the *'Manila Amendments'* to the STCW Convention and additional courses in *Bridge Resource Management* and *Engine Room Resource Management* can be taken. The Manila Amendments include, among others, new requirements for training in leadership and teamwork and require refresh training at least every five years in areas such as crisis management and human behaviour and crowd management. Areas of interest within said courses could therefore be offered to the officers onboard as a complementary source of training, in order to obtain and maintain such skills as teamwork, stress management and crisis management.

However, issues in relation to the development of *social skills* such as *communication and teamwork* may arise due to the regular change of crew onboard. Therefore, this aspect should be taken into consideration especially by the management onboard tankers, where fire drills are done once a month and efforts should be made for a fire drill to take place as soon as a substantial part of the crew has changed. This should also be in accordance with the relevant requirements under SOLAS, which requires a fire drill to be conducted within 24 hours of the ship leaving port when more than 25 percent of the crew has not participated in a fire drill. That will ensure that crew onboard are familiar with each other and practice communication and teamwork during the fire drill. Finally, another important aspect that was mentioned by several interviewees and should be taken into account in relation to social skills, such as communication, is the *nationality* of the crew. That said, having different nationalities onboard a vessel may entail some challenges in relation to the development of some social skills due to the differences in language, culture and background. Therefore, efforts should be made for the crew to practice communication in the working language of the vessel during the fire drills and

to promote a team spirit based on common goals and tasks during fire safety training. Therefore, regular fire drills, briefing and debriefing sessions can be utilized as a method to enhance communication between crew members and to exchange knowledge and experiences.

7.2.3 Suggestions in relation to Fire Safety Training

7.2.3.1 Leadership and Management Engagement

As stated by Tac, Akyuz and Celik (2020) the quality of the training is more important than how often one trains and the responsibility for the quality of the drills conducted onboard is shared between the shore management and the senior management onboard. The result from this study gives the impression that there is a lack of *involvement* from the shore management in the drills conducted onboard. It is much left up to the officers and crew onboard how they choose to train. There is also a gap between what the interviewees believe is an ideal and realistic fire drill and the type of drills conducted and the quality of them seems to be largely dependent on the *drill leader* or the person planning the drill. A way to address this issue would be for the management to incorporate clearer guidance or procedures on how to plan realistic and high-quality drills. Furthermore, another element is the *combination* of different drills such as performing a fire drill together with a medical emergency or abandon ship drill. As the time for conducting drills onboard is limited, providing clear guidance to the crew on how they can effectively combine drills to make them more realistic would also assist the crew in performing effective drills even when short on time.

The senior management should also promote fire safety and improve fire safety training through *'leading by example'.* Therefore, the role of the Master and the officers onboard is crucial in order to create common goals when it comes to fire safety onboard. The engagement of the management onboard the vessel and the exercise of good leadership, also appears to be important for motivating the crew to promote fire safety and to conduct quality fire drills. Another identified aspect that is not taken into account by the officers onboard when planning fire drills, are the lessons learned from previous drills. This is recognized by the shore management, but the officers onboard perceive that they do not receive *feedback* on the reports they have written. The shore management should be to give feedback to the officers onboard when it is deemed necessary.

Furthermore, they should ensure that the officers have the proper *guidance* needed to plan and execute effective drills onboard. As this study has identified that there is improvement potential in the evaluation of drills onboard, it is suggested that the procedure and guidance should cover the evaluation of drills as well. It would then be the responsibility of the senior management onboard to implement these procedures and ensure that the drills that they conduct are according to the procedures. In addition, the senior management and the officers onboard have a responsibility to inform the shore management if they believe that the procedures do not offer the support and guidance needed in planning the drills. This is an issue identified by some interviewees in this study, who stated that the crew and officers onboard are often inconsistent

when reviewing the procedures they have and often neglect forwarding the feedback on the procedures to the shore management.

7.2.3.2 Crew Engagement

Improving the fire safety training onboard should not only be viewed as a management issue or only as a collective commitment, but also as an *individual commitment* for each crewmember. That said, it can be suggested that increasing the competence, knowledge, skills and engagement of the crewmembers will contribute to the elevation of fire safety and the improvement of fire safety training onboard. Furthermore, it can be stated that when it comes to Rules, Regulations and procedures, the majority of the interviewees suggested that increasing the amount or complexity of the procedures onboard will not necessarily result in a better training or higher engagement of the crew. Therefore, it can be suggested that the focus should be on improving the *quality* of the training, in order for the crew to obtain, develop and maintain skills, competence and knowledge, which in turn will support a better fire safety training overall. By developing this competence, the crew should be able to obtain the necessary foundation for becoming more risk aware and proactive when it comes to fire safety, as well as the necessary skills for firefighting and emergency preparedness.

In addition, for increasing the individual commitment of each crewmember, it is important to infuse a sense of *individual responsibility.* That can be done also during fire drills, where every crewmember should be actively participating and contributing. A *rotation* of duties and responsibilities during fire safety training may also ensure that every crew member is actively participating and entrusted with the responsibility of performing the assigned tasks. This may in turn increase the crew's engagement in the fire safety training and their motivation to develop their skills and capabilities. Furthermore, based on the data collected from the interviews, it can be suggested that the creation of *realistic scenarios* for the fire drills conducted may also increase the engagement of the crew. The majority of the interviewees suggested that realistic scenarios are more fun, more useful and more interesting for the crew to participate in and that these types of drills are taken more seriously by the crew. Finally, for having a highly engaged crew, it is necessary to have *highly engaged leaders*. The majority of the interviewees stated that in order for the crew to be engaged and motivated when it comes to fire safety training and fire drills, the onboard and shore management needs to be engaged as well. Therefore, it is suggested that if the senior officers and shore management practice engagement in fire safety training and promote its benefits, the crew will follow.

7.2.3.3 Fire Safety Training Evaluation

Fire drills provide a good opportunity to evaluate the effectiveness and functionality of different procedures and processes in relation to fire safety training, for example the use of checklists. However, there might be a need from the shore management to emphasize the importance of drills as an evaluation method of the emergency preparedness onboard and that the drills must be evaluated in order to improve the emergency preparedness of the crew, but also the procedures. In relation to the use of the *checklists* during drills, this does not only

evaluate the checklist per se, but can also provide guidance on what the drill should include. Therefore, using the checklists often during fire drills can be an efficient method to evaluate whether the crew is able to perform all the required tasks in the list, but also to evaluate the usefulness of the checklist. The same may apply for other procedures and processes in relation to fire safety training, such as the use of *drill matrixes* and other relevant documentation. Such documentation may be used to also evaluate whether the procedures comply with the relevant requirements under the SOLAS and the ISM regulations.

Furthermore, based on the results from this study, it appears that there is also a general need for the senior management onboard to evaluate the fire drills more efficiently, both through *debriefings* and by *lessons learned*. The shore management must therefore emphasize the importance of conducting debriefings after each fire drill and the senior management onboard must ensure that the atmosphere onboard allows for an open discussion during the debriefing. In order to improve the fire safety training of the crew it is important to identify what must be improved and allow for the crew to ask questions if there are any uncertainties. The lessons learned during the debriefing should be addressed in the record of the drill, so that the shore management can assist the senior management onboard in evaluating the drills, and so that the officers onboard can utilize the lessons learned into the planning of upcoming drills.

Some of the interviewees suggested that conducting *internal audits* is also a good method for evaluating the fire safety and fire safety training onboard. For this to be effective and valuable it requires that there is good communication between the officers onboard and the attending auditor from the company. The officers onboard must feel that they can ask questions and provide honest feedback to the auditor without the fear of receiving criticisms. An open and transparent communication between the officers onboard and the shore management will create a relationship of trust, which is important for the continuous improvement of fire safety training and the overall emergency preparedness of the crew as well as the organization as a whole. An internal auditor who is knowledgeable about both the Company specific procedures and the Rules and Regulations will be able to assist the senior officers in identifying any gaps in the fire safety training conducted onboard.

7.2.3.4 Safety Culture Elevation

Furthermore, for improving the quality of the fire safety training onboard, efforts should be made in order to improve the overall *safety culture.* As the safety culture has a large impact on both how the training is conducted and how it is evaluated, the improvement of the safety culture is essential for the successful implementation of any other initiatives to improve the quality of fire drills. If the level of the safety culture onboard is higher, the sense of common goal or a team spirit would also be more present. Then the quality of the drills would be less dependent on the interest of one officer, as planning the drills would be a joint venture between several ranks onboard. In a working safety culture, the competence and the risk and safety awareness of both the crew and the officers would be higher and the importance of effective fire drills and their purpose would corollary be higher. Furthermore, in a sound safety culture

the debriefings would be an active discussion where all share their opinions and questions to increase their own knowledge and performance, but also to share lessons learned to improve the knowledge and performance of the whole crew.

In order to elevate the safety culture, the promotion of a *no-blame culture* should be considered for improving the fire safety training onboard. In practice, that means that during fire safety training and fire drills, crewmembers should be able to make mistakes and ask questions regardless of rank or years of experience and that crew should be able to provide constructive criticism to officers. The crew should also be able to ask questions and exchange experiences in order to learn from each other. This can be done during fire drills, especially during briefings and debriefings when the crew can raise questions in relation to aspects relevant to fire safety, firefighting and fire prevention. For elevating the safety culture, it is also important to increase the *engagement* of both the crew and of the management onboard in relation to fire safety training. The engagement of the management is relevant also in relation to the shore management, by regularly providing guidance and feedback in relation to fire safety training and fire drills and in relation to the onboard management, having a Master and officers that *'lead by example'*. Debriefing reports may be a useful tool in this process, thus emphasizing further the importance of conducting a debriefing after every fire drill conducted onboard.

In addition, the engagement of a *competent and skilled crew* is also important for creating a strong safety culture, therefore active participation of all crewmembers in quality fire drills is essential. It can be suggested further that strengthening the crewmembers' skills may also contribute positively to the elevation of the safety culture onboard. That said, having a crew with strong communication and teamwork skills, a sound theoretical knowledge and good practical skills will assist in the elevation of the safety culture and ensure a high-quality fire safety training onboard. Finally, based on the data obtained from the interviews it can be argued whether or not the applicable *Rules and Regulations* may have a positive impact on safety culture and fire safety training onboard. Even though the opinions of the interviewees varied, the majority believed that having meaningful Rules and Regulations may increase the safety culture onboard and improve the quality of the fire safety training. However, this may not be done solely by their existence, but through successful implementation, flexibility in their use based on specific needs and by the engagement of knowledgeable and skilled personnel.

8. Conclusions

The findings in this research indicate that the *skills* that are considered important for the crew to obtain through fire safety training can be divided into three categories, being *Practical*, *Theoretical* and *Social*. In relation to the *Practical* skills, identified areas of interest appear to emerge in relation to the use of the equipment and systems onboard, the fireman's outfit and gear and the establishment of ship-specific and cargo-specific knowledge. However, some gaps in the training were identified that may be in contradiction to the applicable requirements under the SOLAS and the ISM Code. These are aspects such as the lack of training with pressurized hoses, the use of fire doors and of ventilation control as part of the fire safety training, as well as lack of knowledge about Dangerous Goods. In relation to the *Theoretical* skills, these refer primarily to knowledge about Rules and Regulations, to the ability to make risk assessments and be risk aware and to obtain knowledge about the theory of fire. Interesting findings in relation to theoretical skills, was the difference in the requirement of obtaining and developing said skills between the crew and the officers onboard, as well as the critique on the usefulness of acquiring knowledge in relation to Rules and Regulations. When it comes to *Social* skills, emphasis should be given to communication, teamwork and leadership and interesting findings emerged in relation to how these skills may be developed during fire drills, as well as, in relation to the interplay between these skills and their impact on fire safety training. Based on the findings of this research it can be suggested that a combination of the above three categories of skills would be ideal and developing skills should be viewed as a continuous process. That said, factors such as existing and upcoming Regulations, but also the use of new technology onboard may have an impact on the skills that crew should obtain through fire safety training and create new needs and new challenges.

Furthermore, based on the data collected from this study, it can be concluded that there is a minor gap between the requirements according to SOLAS and the ISM Code and how fire safety training and fire drills are actually conducted in practice onboard. These gaps refer to different aspects in relation to the skills that the crew should obtain, to the quality and content of drills and to the evaluation of fire drills. In addition, it can be concluded that to achieve a higher quality of fire safety training and fire drills onboard, more than Regulation and Procedures is required. The *factors* that have the largest impact on how fire safety training and foremost the fire drills onboard are conducted are intangible factors such as the *Leadership* onboard, the *Safety Culture* and the level of *Knowledge* that the crew and officers have. A good Safety Culture onboard, together with dedicated and knowledgeable officers and crew may have a direct positive effect on the fire safety training, whereas the lack of them may have indeed a negative effect. On the other hand, Rules and Regulations, and the verification of compliance with these through internal and external audits and inspections appear to have a minor impact on fire safety training. Therefore, it is suggested that in order to improve the quality of the fire safety training, focus should be given to the *Leadership*, *Safety Culture* and *Knowledge* of the crew and officers onboard and by strengthening the human element.

9. Future Research

The subject thesis has focused on a limited number of *interviewees* that have working experience as officers onboard tankers and Ro-Ro/Ro-Pax vessels, as well as, interviewees within the shore management. Future research in relation to fire safety training and fire drills could include a larger sample of interviewees from different ranks, where a comparison can be made between the skills that ratings should obtain compared to the skills that officers should obtain through fire safety training. A larger sample of interviewees from different ranks would also provide a wider and more global perspective in relation to how crew onboard trains for fire safety and firefighting preparedness, as well as, on what aspects affect the outcome of fire safety training. Having more interviewees from different ranks would also provide a deeper and more comprehensive understanding of the impact that safety culture onboard has on fire safety. That is because safety culture appears to be an important subject for officers onboard, however, it is not clear whether this would be a priority between crewmembers of lower ranks.

Furthermore, the subject research focused on interviewees working for companies with Swedish ownership and/or management, however, future research would benefit from including other Scandinavian, European or International shipping companies. This would enable future researchers to make constructive comparisons of the collected data and find similarities and differences in relation to fire safety training between different cultures, different nationalities and different management styles. That said, the subject thesis did not take into account any influence that flag states may have on the fire safety training onboard, therefore, future research could also include this aspect in their analysis. That is due to the fact that differences may exist in relation to fire safety training onboard depending on the flag requirements and interesting data may arise in relation to this aspect. This aspect was also brought up by one of the interviewees, who mentioned that on Swedish flagged vessels, the Chief Engineer is the fire chief, however, on other flags this responsibility is shared between the Chief Engineer and the Chief Officer. Based on the results of the subject thesis, it appears that the role of the fire chief is indeed crucial in relation to the quality of the fire drills. Therefore, it can be suggested that future research may analyse the impact of having two individuals onboard who share the duties of the fire chief and how this may influence the quality or content of the fire drills or the fire safety training onboard.

Another suggestion for future research in relation to fire safety training and fire drills, would be to include interviewees with working experience from other types of vessels, such as container vessels. That would enable the researchers to compare the results with the data relating to tankers and Ro-Ro/Ro-Pax vessels and identify any differences or similarities within these sectors in relation to fire safety training. This would be particularly interesting considering the comments from one of the interviewees with experience from the marine insurance market, who suggested that a large percentage of fires appear to be on container vessels. Some of the reasons behind this comment appear to be the very large number of container boxes onboard this type of vessels, which contain different types of cargoes that are often unknown, as the containers are closed and sealed. Therefore, the large size of these

vessels, the carriage of non-homogeneous cargo and of Dangerous Goods, as well as the possible misdeclaration of cargo within said containers, may suggest the requirement for specialised fire safety training and fire drills for crew working onboard container vessels. Future research may therefore focus on these aspects and provide useful and interesting findings that may advance the fire safety onboard container vessels.

Appendix I: Questions / Structure for Interviews

Informed Consent

The aim of this interview is to investigate how fire drills and safety training is carried out onboard vessels and in relation to the rules and regulations. The interview will be used for a research project in the programme *Maritime Management* at Chalmers University of Technology, Department of Mechanics and Maritime Sciences. The data will be compiled in a Master Thesis which will be published at Chalmers University of Technology.

The results will be presented with neither the name, age, gender nor employer of the interviewee. Your name will be kept anonymous throughout the research. The interview will be recorded for data analysis purposes. The recorded material will be treated with confidentiality and will only be available to the researchers and the supervisor of the project. The completed interviews will not be used for any other purpose than this research project.

The participation in this research is voluntary, by answering 'yes' to this information you give your consent to that the data is used in the research. You have the right to withdraw your participation in this research at any time. Questions regarding the research project and the interview are answered by the researchers.

Best regards,

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Interview Questions

1. Background

- What is your background in terms of education and working experience? Years at rank?
- What is your experience with fire safety and/or fire safety training onboard or ashore?

2. Training needs

- In your opinion, what should the fire safety training for crew include and why?
- In your opinion, what kind of skills should crew obtain through fire safety training?
- How important do you think it is for the crew to be aware of applicable Rules and International Regulations in relation to fire safety or fire safety training and why?
- What are the most important procedures (in SMS) in place with respect to onboard fire training / drills? How are these procedures (in SMS) evaluated?

3. Training conducted

- How should fire drills be conducted in your opinion and what should they include? (onboard? ashore? equipment?)
- When and how often do you think that fire drills should be conducted? (when joining for the first time? monthly?)
- How often are fire drills actually carried out onboard in your experience?
- Describe a "typical" fire drill carried out onboard - including planning, decision of scenario, equipment to be used, etc.
- What do you believe is the most important component of a fire drill that must be trained / practised during the drill?
- What do you believe is the most important learning that can be gained from a fire drill?
- Except from fire drills, are there other aspects of fire safety training that you consider important and why?

4. Outcomes

- How useful or important do you consider that the reporting of incidents involving fire onboard is and why?
- How useful or important do you consider to be having internal and external audits or surveys in relation to fire safety and training?
- How important do you think is the safety culture onboard in relation to the outcome of (fire) safety training? (attitudes? priorities? risk awareness?)

5. Shore-based personnel

- How do external parties evaluate drills?
- What documentation or records of drills are required to keep?

6. Follow-up questions

- In your opinion, do regulations raise/improve the safety awareness onboard?
- Is there a debriefing after every fire drill?
- In your opinion, are there any components missing in fire drills onboard?
- Other

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