

THE IMPACT OF SAFETY CULTURE ON MARINE ENVIRONMENT

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Abstract. Maritime safety is the comprehensive term of the safety of individuals and marine environment. However, the meaning of safety culture, which is part of the maritime safety at sea, is the culture of the human factor and the ship management with all the aspects related to the human factor. Considering the marine accidents, 80% of maritime accidents are due to human error and the consequences of these incidents that affect the marine environment.

Safety culture is one of the basic factors that cause maritime accidents and thus affect the marine environment because it is the direct link between the management, the vessel, and individuals with each other. Besides, the International Maritime Organization (IMO) has set the International Safety Management system (ISM) code to identify regulatory controls to manage the ship, but the importance of safety culture was not highlighted in this code because it is an intangible culture and thus it was not mentioned in the code, but due to its seriousness, the IMO began to introduce the meaning of safety culture and its gravity.

Due to the impact of safety culture on the marine accidents, the SHEL investigation model (Software, Hardware, Environment, and Liveware), which is used in analyzing the human factors to identify the actual causes for accidents was amended by introducing the factor of safety culture to be SCHEL investigation model (Software, Culture, Hardware, Environment, and Liveware) to determine the causes leading to accidents in a thorough way. This research paper will define the meaning of safety culture and analyze the impact of safety culture on the marine environment. In addition, it will explain the proposed procedures to decrease the human errors, which negatively affect the marine environment.

Key words: Safety Culture, Human Factor, SHEL Investigation Model, SCHEL Investigation Model.

1. Introduction

The maritime transport sector is directly affected by marine accidents, which adversely affect the human and marine environment, as well as properties and activities onboard ships and ashore in various forms. The effects of accidents vary from minor injuries to fatalities and from insignificant damage to severe damage to the environment and property. Marine accidents affect marine environment in different ways, not only grounding and collisions are the reasons of marine pollution, but also human errors as oil spillage, solid waste, oil transfer or bunkering spills cause marine pollution. Therefore, The International Maritime Organization (IMO) have set different goals for protecting human and the marine environment, and also properties by issuing maritime safety treaties and codes such as: The International Convention for the Safety of Life at Sea (SOLAS) 1974, as well as the International Convention for the Prevention of Pollution from Ships (MARPOL) 1973, that are related to the protection of the marine environment from oil spills, sewage, garbage, and early air emission.

However, the IMO also issued the International Safety Management (ISM) Code, which is a code established to provide an international standard for the safe management and operation of ships and for pollution prevention. Marine accidents still occurs on different types of vessels as shown in Figure (1), which shows the retreat in the number of lives lost onboard vessels especially onboard cargo ships(ICS, 2013).

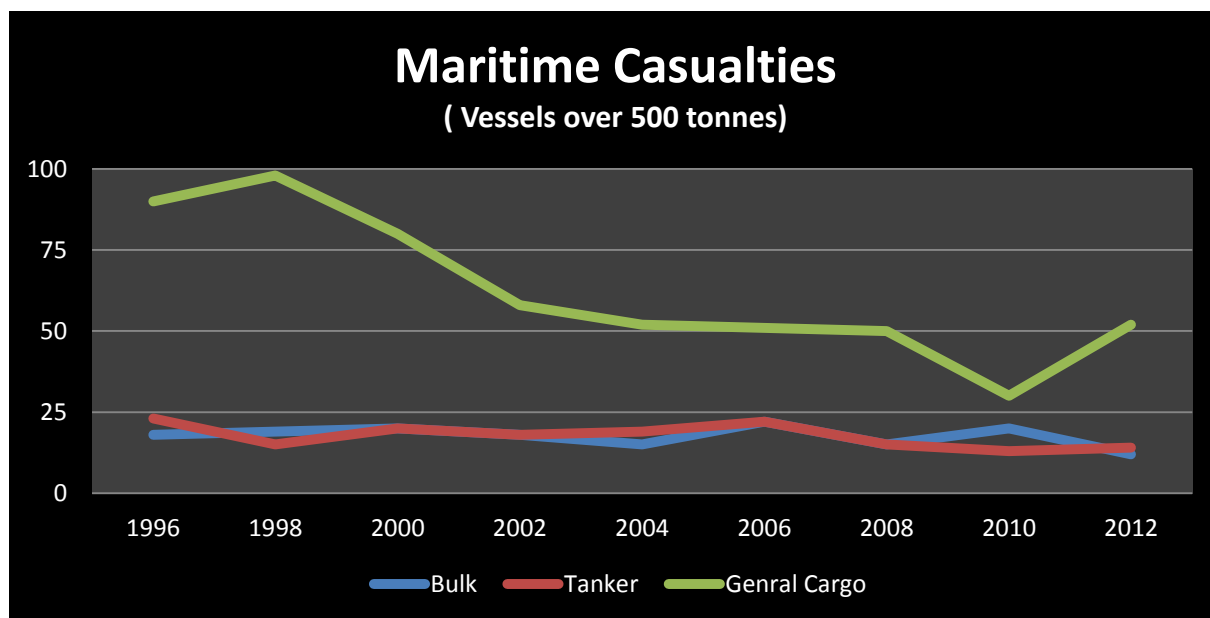


Figure1. Number of Total Lives Lost

Source: International Chamber of Shipping, (2013).

As mentioned before, the marine accident and marine casualties decreases by implementing the IMO conventions, ISM code and other related codes, so the IMO started searching for the main reason for the continuous occurrence of marine accidents, until it found that the main factors in this system are the company and the human element, but the question is what is the relation between these two factors, the answer is, marine safety culture, which is a tool used to help the maritime system to operate in a safe environment, which also aim to reduce accidents and thus protect safety of lives, and the marine environment (*Havold, 2005*).

This research paper will explain the concept of safety culture and its impact on the marine accidents and marine environment. In addition, it will analyze the SHEL investigation model (Software, Hardware, Environment, and Liveware), which is used in analyzing the human factors to identify the actual causes for accidents, which was amended by introducing the factor of safety culture to be SCHEL investigation model (Software, Culture, Hardware, Environment, and Liveware) to determine the causes leading to the marine accidents in a thorough way. Moreover, the paper will describe the proposed procedures to decrease the human errors, which affect the marine environment. The structure of this paper consists of a clear introduction about safety culture, explanation of the new SCHEL investigation model, and finally comes the conclusion & recommendations.

2. The Concept of Safety Culture

In order to be able to understand the impact of safety culture on the marine accidents and marine environment, investigations of marine accidents should be carried out in order to reach the correct concept of this culture. The following figure (2) shows the result of investigating a number of large spills (over 700 tones) of marine accidents from 1970 to 2012, the statistics show that the number of large spills (over 700 tones) has decreased significantly during the last 42 years. The average number of major spills in the previous decade (2000-2010) it is more than three, approximately eight times less than in the 1970s. Looking at this downward trend from another perspective, 55% of the large spills recorded occurred in the 1970s, and this percentage has decreased each decade to 7% in the 2000s (IMO, 2012). However, the statistics show that the number of major oil spills has declined, but marine accidents still occurs due to the error of the human element, which results from the misunderstanding of safety culture onboard the vessels. Therefore, the concept of safety culture has to be clear to those working onboard so as to avoid the human element error, which will consequently result in the drop of the number of marine accident.

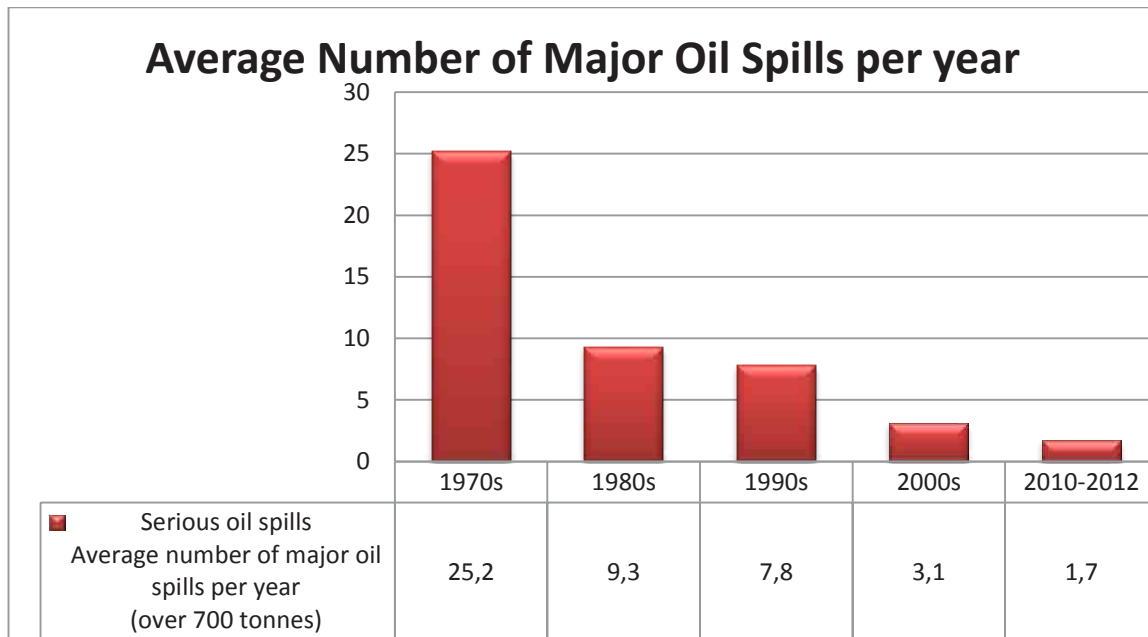


Figure2. Large Oil Spills (over 700 tones) from 1970 to 2012

Source: *International Chamber of Shipping, (2013).*

2.1 Definition of Safety Culture

The marine safety culture is one of the most important factors in the real marine system, whether onboard or in the management system, so the true meaning of safety culture have to be defined as follows; it is the attitudes, beliefs and perceptions shared by natural groups as defining norms and values, which determine how they act and react in relation to risks and risk control systems (*Butalia, 2014*). Safety culture can also be defined as a culture that requires multiple efforts to reduce the risks resulting from individuals, ships or the surrounding environment. This goal can be achieved through the actual application in the work environment and organization of work through economic and social development and the proper balance between safety and trade (*Rusconi, 2013*). In addition, developing safety culture with the effective and correct application of human factors plays a vital role in the implementation of health, safety and environmental protection policies. Safety culture is defined in a number of different ways, but generally contains the following elements: it is a concept defined at group reflects on the shared values among all the shipboard, shore side, and organization members, it is concerned with formal safety issues within an organization, it reflects the organization's willingness to develop and learn from errors, incidents, and accidents, it also embraces communication and teamwork (*Zhang et al., 2004*).

3. Elements Affecting Safety Culture

As mentioned above, there are a number of elements that affect safety culture and understanding them onboard the vessels and also at shore s a must. Firstly, safety culture reflects all organizational and behavioral attitudes and clarifies all rules governing individuals in the maritime system. Secondly, safety culture is the first priority that preserves human life and marine environment and not the all maritime system as a result of operational, environmental and social conditions. Thirdly, safety culture is regulated through attitudes, standards and behaviors, which is the way in which issues and situations are managed. Finally, the last element that affect safety culture that it is linked to the provision of a safe voyage beside that each person onboard must perform his duties in a safely manner to fulfill the final objective of the voyage which is that the vessel run safely, bearing in mind the safety and the protection of the marine environment.

As a result, it have been approved that safety culture depends on two main elements, namely the organization and the human factor, however, the human factor is the influential factor that deals with the marine system as a whole, so it was found that understanding the concept of safety culture is the main goal that develops the individuals as well as the entire marine system. Therefore, the next step will be an explanation of the elements affecting safety culture, and lead to marine accidents and harm the marine environment.

3.1 Fatigue Element

There are many human elements influencing safety such as fatigue, automation, situation awareness, poor communication, and stress. These individual elements can be contributory causes in accident causation; however, the safety climate on the vessel is also influence whether or not an individual engages in safe practices. One of the most important elements affecting safety culture is fatigue. According to the IMO, fatigue can be described as a state of feeling tired, weary and sleepy, which results from mental and physical pressure over a period of time (*IMO, 2007*). By analyzing a number of the marine accidents, which led to loss of life and pollution of the environment, the result was that 86% of these accidents were due to lack of sleep. Failure to sleep for six continuous hours may lead to a lack of concentration at work. The work done by the crew whether during watch- keeping watches or daily routine work and during the loading and discharging operations may lead to marine accidents (*MIAB, 2004*). The following figure (3) presents a number of factors that affect the crew and leads to accidents and incidents. Here comes the role of safety culture in protecting the environment by making all individuals involved aware of safety to organize work properly

and give the crew the required rest times onboard, which consequently reduce marine accidents.

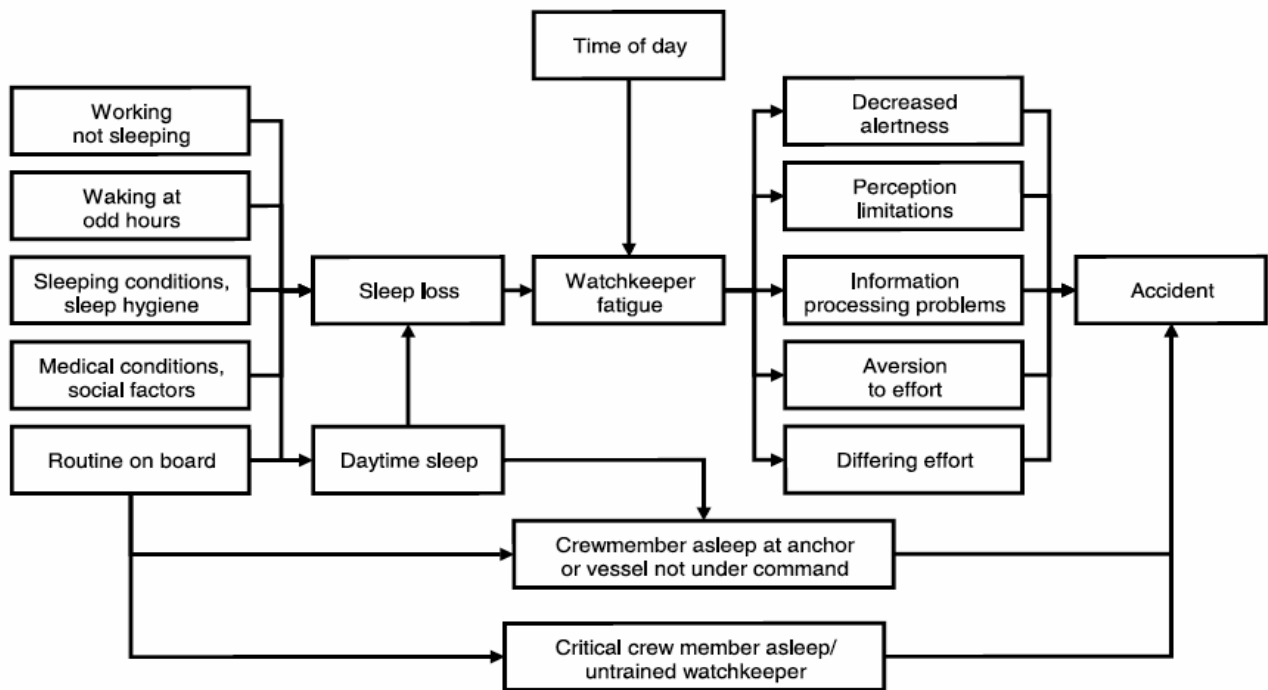


Figure 3. Relationship between Sleep Loss, Fatigue, and Accidents

Source: Phillips, (2010).

3.2 Communication Element

To start with, the process of communication is a complex process and one of the key elements in safety culture, it is well known that most of ship owners tend to have different nationalities onboard, using different languages and cultures, which lead to marine accidents and damage the marine environment. The failure of the communication process or the difference in communication language harms the marine system, as it interferes with the work environment onboard, as understanding among the crew becomes difficult, which leads to written errors due to not understanding the orders and the inability of applying the application of safety on the ship, especially in the process of loading and discharging the ship and also during sailing or berthing in ports (Pyne& Koester, 2005). An example of maritime accidents resulting from the failure of the communication process is the vessel “Costa Concordia”, in which the helms man did not understand the captain's orders in changing the ship course due to difference in nationality and difference in the English language accent.

Statistics shows that the communication process is one of the basic problems, which affect safety culture, as it is one of the main causes of marine accidents that results in injuries and deaths as shown in figure (4).

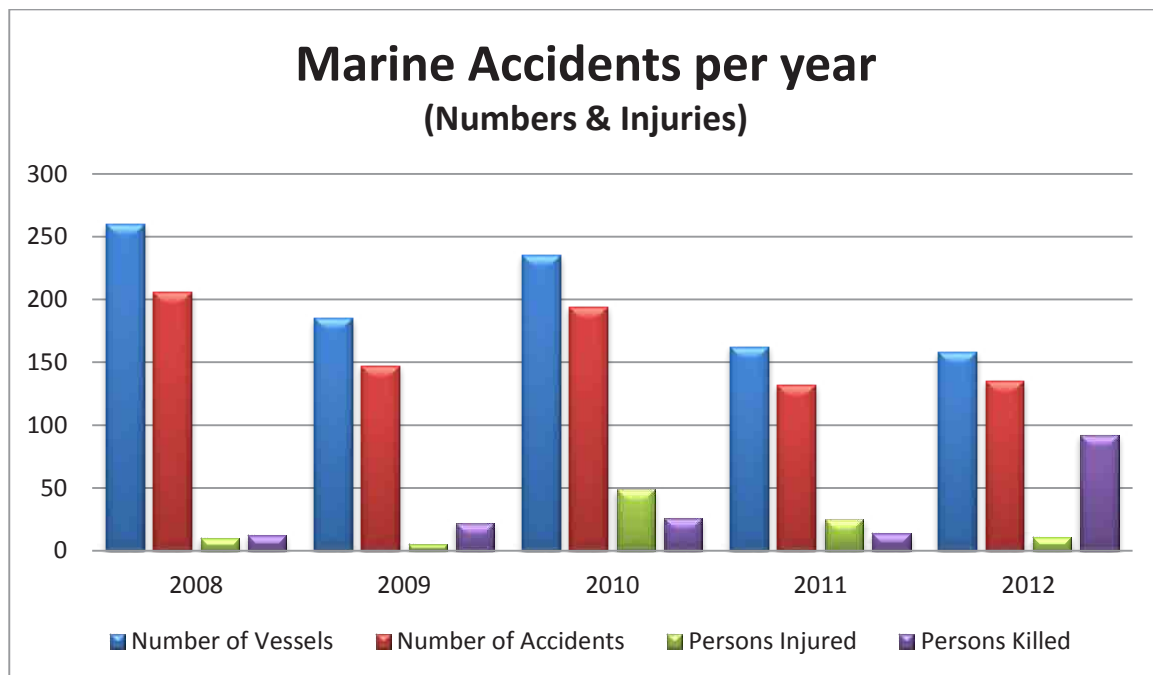


Figure 4. Marine Accidents from 2008 to 2012

Source: Ceyhun, (2014).

In many countries, marine accident data is recorded in the database of the maritime administration, this statistics is officiated by Turkish Ministry of Transport, Maritime Affairs and Communications. According to Ministry’s reports, figure (4) shows a number of vessels involved in maritime accidents and incidents, persons killed and persons injured in the years from 2008 to 2012. These statistics include both Turkish flagged and foreign flagged vessels, 206 accidents occurred in Turkish Seas in 2008,147 in 2009, 194 in 2010, 132 in 2011 and 135 in 2012, so the figure shows that accidents are still happening, but in 2012 the number of persons killed due marine accident increased, which indicates the absence of understanding of the concept of safety culture (Ceyhun,2014). Therefore, the administration should conduct personal interviews and make sure that the new members know the meaning of safety culture and understand the communication process among the crew onboard before assigning those members to the ship. Those working onboard should attend safety meetings so that they can communicate together, reduce falling in incidents, and protect the marine environment from pollution.

4. The Process of Measuring and Investigating Safety Culture

An organization that decides to improve and measure its safety culture should follow a systematic, closed-loop process, which is presented in the following figure (5).

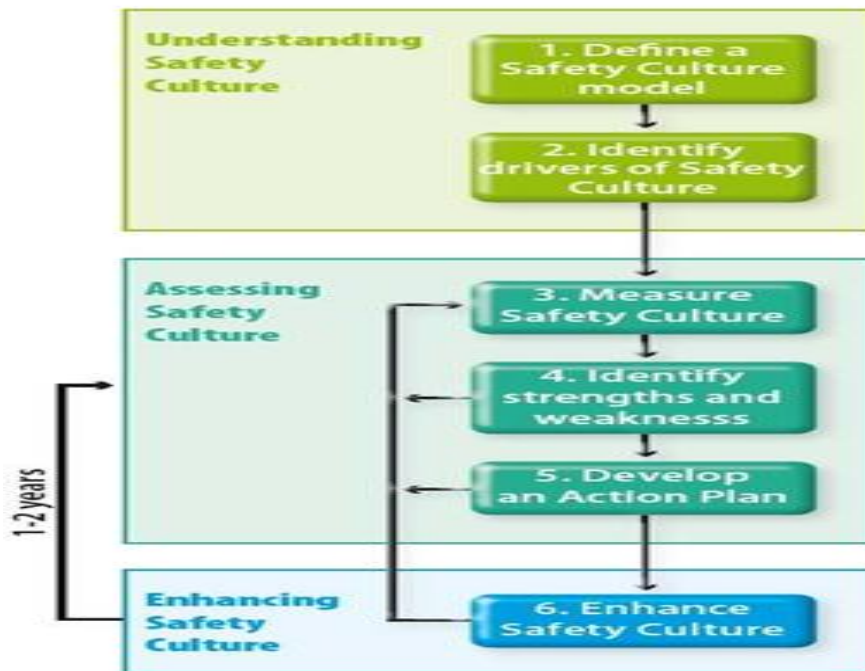


Figure 5. Measuring Safety Culture Process

Source: Berg, (2013).

The first phase consists of defining safety culture and understanding the meaning of safety culture in the management perspective of the organization. This requires identifying the characteristics of safety culture to look at, and their sub-components, these first two steps are important to measure safety culture effectively. The next phase of the process is the assessment stage, where the organization carries out a survey to measure its own safety culture, Surveys and other techniques contribute to the identification of strengths and weaknesses of safety culture. Based on this assessment, an action plan is developed, in which these actions help to improve safety culture, and then after a reasonable period, safety culture can be assessed again to determine if the organization situation has improved.

In addition, investigating safety culture depends on the human factor, which is the basis of the investigating process. The initial idea in the investigation of the human factor was SHELL model, which depends on the investigation of the human factor and in terms of the maritime system. The basic principle of the SHELL model is dividing the whole ship system into four elements: Software, Hardware, Environment, and Livewire. First, the Software presents the regulations, manuals, procedures and some other irrelevant things related to

maritime transport system; Hardware means the physical materials such as equipment, tools and the ship hull; Environment includes the internal and external climate, temperature, vibration, noise and other factors which constitute the conditions under which people are working; and finally Liveware which is the people working onboard (*Zeng & Gao, 2010*). The most essential element of the SHEL Model is the Liveware, which is the subject of accident investigation, since that element interacts with all the other elements in the system. According to the SHEL model, the unsmooth interaction between these people and the other elements is the cause of the marine accidents.

5. Relation between the Elements of SHEL Model

To begin with, the relation between the Liveware and the Hardware. this relation show the search and scrutiny between the treatment of human and physical objects, which is called man-machine and here the investigation process shows the human handling with the existing devices and equipment(*Hawkins, 1987*).Secondly, the relation between the Liveware and Software , which is the search and scrutiny between the treatment of humans and intangible things, and here in the investigation, internal information should be looked at in the devices and the introduction of information and whether it is true or not. Knowledge-based mistakes which refers to those faults resulting from ignorance, inadequate knowledge or the misunderstanding of some critical principles. The related personnel do not know how to respond to and handle some situations, therefore they make mistakes. These kinds of mistakes seldom happen to highly educated officers and engineers. However, for sailors and motorman, if these mistakes are not duly corrected, accidents may take place. Skill-based mistakes often occur due to insufficient working experience, such as inefficient drilling, inadequate practice and lack of experience exchange with other colleagues. Rule-based mistakes are the consequence of incorrectly using the rules, or the self-righteous application of a simplified rule (*Reinhont, 1996*).

Thirdly, the relation between the Liveware and Environment can be shown in the ship system, the environment includes the external environment, such as the natural condition, fairway condition and the internal work environment, such as temperature and ship's movement. Different from other interactions, in most cases people can do nothing but adapt themselves to the environment around them. The internal work environment directly affects one's ability to perform. For example, the human body performs best within a restricted temperature range. Performance will be degraded at temperature outside that range, and fail altogether in extreme temperature for example in the boiler room (*Zeng & Gao, 2010*). Finally,

the relation between the Liveware and Liveware can be clear in the way of communication barrier, which means any disturbing, blocking, or break down of communication, which could be physical or man-made. The physical barrier onboard ship includes noise, distance and vibration; while the man-made barrier includes different languages, accents, speed and pronunciation which results in misunderstandings. The ship is a mini society, seafarers come from different parts of the world and different countries on open-registered ships. They have different cultural backgrounds, habits, personalities and moral levels. However, they have to work together for several consecutive months. It is normal for them to have different opinions. If these conflicts accumulate gradually and without an effective abreaction, they will erupt and seriously destroy the harmony of teamwork, which may result in accidents (*Kebabjian, 2005*).

However, given the method of investigation, the element of safety culture has not been addressed in the investigation process, and the importance of this marine element and its impact, which leads to marine accidents. The SHELL theory has changed into a new model in which safety culture has been developed and transformed into SCHEL. Therefore, safety culture has been developed to force the investigator to investigate this element mentioned before, so in this context, during the investigation of marine accidents, the investigator must begin to investigate the element of the safety culture, and how people treat and understand each other, whether in communicating with each other, or during training and safety drills, or while facing emergency situations or dealing with the vessel equipment and confirming how to use safety technology in the real sense of ship safety (*Eral, 2006*). In addition, it has to be clear that the concept of investigating the root cause has differed in that it is necessary to deal with safety culture and its importance to the human element, so the IMO can conduct appropriate maritime safety community and set restricted measures for environmental protection.

6. Conclusion & Recommendation

In general, safety culture has been found to be important across a wide variety of organizations and industries. While initial studies of safety culture took place in jobs that have traditionally been considered high-risk, Moreover, the evidence recommends that safety culture may not be the only determinant of safety in the organizations, but it plays a substantial role in encouraging people to behave safely. The essence of safety culture is the ability and willingness of the organization to understand safety, hazards and means of preventing them, as well as ability and willingness to act safely, prevent hazards from happening and promote safety.

Safety culture also refers to a dynamic and adaptive state; it can be viewed as a multilevel phenomenon of social processes organizational dimensions, and psychological

states of the personnel. The achievement of an effective safety culture is recognised to be a vital element of achieving and maintaining satisfactory levels of safety performance. A Systematic Safety Culture Enhancement Process is a managerial tool allowing organizations to identify areas where safety culture may be enhanced. The enhancement process moves onto measuring and evaluating safety culture. There are many available tools for measuring and evaluating safety culture. The selection of the appropriate measurement tools begins with the model and takes many factors into effect including but not limited to cost, time, confidentiality requirements, ease of data analysis and usefulness of output for planning of enhancement actions. It is important to recognize that the Systematic Safety Culture Enhancement Process is a closed loop system. Following implementation of enhancement actions, an organization must begin again by measuring safety culture to determine the impact of those actions.

The Safety Culture can be improved on board the vessels by training the crew, because training is one of the vital processes on which safety culture depends on, as well as the staff and management level to be aware of safety culture. Also, the IMO in its MARPOL, and SOLAS Treaties called upon safety culture to reduce the risk of loss of life and to protect the marine environment. Training depends on three axes: Conducting the necessary training when a new treaty is signed by both ILO & IMO, training on modern techniques whether on communications onboard or in land as well as modern techniques in all equipment on board, and training the ship crew to increase knowledge and transfer experiences among members of the same system. Therefore, the training process helps in raising the safety level on board ships or in a more precise sense of safety culture, which raise the efficiency of staff and personnel in the process of maritime safety and environmental protection in all situations that people are exposed to in dangerous situations such as marine accidents and pollution of the marine environment.

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