Prevention of Occupational and other Accidents During Cargo Related Operations Onboard

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Research based suggestions to eliminate accidents during cargo related operations onboard ships

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Executive Summary

This research is based on cargo related accidents incurred from 1st January 2015 to 31st December 2019 on ships registered or accident investigations carried out by nine Administrations. Cargo related accidents mean accidents occurred during cargo loading/discharging operations and other operations onboard which have a connection with the cargo. Out of the total accidents during the period, 25.6% of the accidents had occurred during cargo related operations causing 132 deaths/missing crew, 69 injuries and 18 cargo/ship damages without injuries. These include masters, deck officers, deck ratings, engineering officers, engine ratings and port workers.

Highest number (40%) of cargo related accidents had occurred onboard bulk carriers. About a decade after the implementation of the ISM Code with the aim of eliminating human error, 81% of the cargo related accidents had occurred due to seafarer's human errors and SMS was not complied in 67% of the accidents. 23% of the accidents that had taken place due to cargo gear, cargo movements & moving objects. After having regulations, procedures and drills, accidents due to enclosed space entries are the second highest at 16%. It is also important to note that more than 50% of the injuries/deaths due to entering enclosed spaces were taken place due to incorrect emergency handling procedures.

Various safety measures shall be taken by IMO, flag states, port states, ship owning/managing companies, seafarers and other stakeholders of the industry for the purpose of eliminating accidents during cargo related operations. Inter alia, these recommended safety measures include:

- IMO to consider of making it mandatory to use an 'approved documented system' ('approved SMS') while the master is required to review it periodically.
- Amendments to the STCW Code.
- Adopting of new regulations.
- Onboard training on risk assessment, obtaining and maintaining situational awareness for seafarers who were certificated prior to the Manila amendments to the STCW Code etc.

Contents

1. Introduction

An occupational accident is an unexpected and an unplanned occurrence, including acts of violence, arising out of or in connection with work which results in one or more workers incurring a personal injury, disease or death [1]. Therefore, material damages and pollutions cannot be considered as occupational accidents if no person is injured. But, during day-to-day operations onboard ships, not only the occupational accidents but other accidents which cause material damages and pollutions may also occur. All these accidents may occur during any operation onboard ships. Operations onboard cargo ships can be mainly categorized as below:

- Navigational watchkeeping
- Engineering watchkeeping
- Cargo related operations
- Maintenance related operations
- Mooring operations
- Training and drills
- Bunkering operations and
- Catering

For the purpose of this research, cargo related operations mean any duty or any operation that has a connection with the cargo onboard or carried onboard. This includes loading, discharging, preparation of cargo holds/tanks for next loading, opening/closing cargo holds for cargo loading/discharging, cargo shift/liquefaction etc. During cargo related operations, occupational accidents as well as other accidents which may cause material damages and pollutions may also occur. This research is based on occupational accidents and other accidents occurred during cargo related operations onboard.

Sometimes, it is little difficult to draw lines separating accidents which occurred while carrying out cargo related work and maintenance work. Therefore, some of the accidents analysed in this research are not exactly cargo specific accidents, which means those types of accidents could occur while carrying out maintenance work as well. But those accidents are also addressed here as they had direct connections with cargo or cargo operations. As an example, if a person has fallen into a cargo hold while climbing down to remove cargo residues, that accident has been taken into consideration in this research. If the same accident had happened while climbing down for maintenance purposes, then the accident is not considered in this research.

Most accidents happened while performing daily routine duties [2] and most importantly, the deck department is carrying the highest risk of on-duty accidents [3]. When comparing the duties conducted by all the departments (deck department, engineering department and catering department) onboard cargo ships, cargo related operations can be considered as the most diversified operation onboard, which also has a higher risk.

According to Erkan çakır and Serim Paker [4] out of 311 injured seafarers:

- 45 were injured during Loading/Unloading cargo
- 30 were injured Cleaning in tank/hold
- 07 were injured during Lashing and unlashing of cargo

According to the above figures 82 (26%) (total of above) seafarers were injured during cargo related operations. In addition to these 82 injuries, 25 injuries had taken place in connection with enclosed spaces. Among these 25 injuries there could have been enclosed spaces with cargo or cargo residues. If it is so, the number of injuries due to cargo related accidents will increase further.

It means that, after so much of hard work by the International Maritime Organization (IMO), the International Labour Organization (ILO), flag states, port states, shipowners and other international organizations, the risks are still high with regards to accidents (occupational accidents and other accidents) during cargo related operations.

Cargo related operations onboard ships are an integral part of seafarer's duties which need high training and competencies in order to maintain a zero-accident environment. Deck officers, deck ratings and port workers are the front-line players of the cargo related operations onboard. If the deck officers and the deck ratings are properly trained and competent, cargo operations related accidents can be reduced significantly.

However, the chances are that accidents still occur regularly and the need to address and re-assess the related underlying issues remains if future incidents are going to be avoided or reduced [5]. Therefore, it is important to address and re-assess the accidents occurred during cargo related operations in order to identify the preventive measures for the protection of the cargoes, ships, environment and the future seafarers.

2. Aim of the research

International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW)'78 as amended, is the main Convention which describes the minimum requirements relating to training, certification and watchkeeping of seafarers.

The aim of this research is to analyse the accidents which occurred during cargo related operations between 1st January 2015 and 31st December 2019 on board cargo carrying ships of 500 Gross Tonnage (GT) or more, not engaged in Near Coastal Voyages (NCV) to:

- Identify the causes of such accidents.
- Evaluate the efficacy of Knowledge, Understanding and Proficiency (KUP) that is required to be gained by the deck officers and deck ratings as given in the respective Tables of the STCW Code and
- Identify means of eliminating such accidents

The competencies and KUP that must be gained by the deck officers and the deck ratings with regards to the cargo related operations are addressed in the below Tables of the STCW Code:

- Table A-II/1 – Certification of officers in charge of a navigational watch (Operational Level) on ships of 500 GT or more
- Table A-II/2 – Certification of masters and chief mates (Management Level) on ships of 500 GT or more
- Table A-II/3 – Certification of officers in charge of navigational watch and Certification of masters on ships of less than 500 GT engage on near coastal voyages (NCV)
- Table A-II/5 – Certification of ratings as able seafarer deck
- Table A-V/1-1-1 – Basic training for oil and chemical tanker cargo operations
- Table A-V/1-2-1 – Basic training for liquified gas tanker cargo operations
- Table A-V/1-1-2 – Advanced training for oil tanker cargo operations
- Table A-V/1-1-3 – Advanced training for chemical tanker cargo operations
- Table A-V/1-2-2 – Advanced training for liquified gas tanker cargo operations
- Table A-VI/1-4 – Personal safety and social responsibilities

The contents of the above Tables of the STCW Code are analysed when evaluating the competencies and KUP that the deck officers and the deck ratings should have achieved to avoid the accidents.

3. Exclusions

Following types of vessels are excluded from this research as they may require different types of training than those mentioned in the STCW Code:

a) Supply vessels
b) Dredgers, drilling vessels and other similar types
c) Tugs
d) Fishing vessels
e) Vessels of less than 500 GT and engage in NCV
f) Passenger ships and
g) Other vessels which do not apply the STCW Code

Vessels of less than 500 GT engage in NCV (Table A-II/3 of the STCW Code) are excluded from this research, because the cargo operations related competencies and KUP that must be gained by deck officers and masters holding such certificates may be decided by the individual Administrations as they are applicable only for ships that are engaged in near coastal voyages. Which means that the standards of competencies of deck officers and masters holding certificates in accordance with Table A-II/3 of the STCW Code may differ from country to country. Therefore, it is difficult to carry out an evaluation of competencies that the seafarers holding such certificates without knowing the training that they have undertaken. But the training provided for seafarers under the other tables listed above are required to be standardized worldwide as these tables are applicable on ships that engage in worldwide trade.

Table A-V/1-2-1 (Basic training for liquified gas tanker cargo operations) and Table A-V/1-2-2 (Advanced training for liquified gas tanker cargo operations) are not considered in this research as there were no cargo or cargo operations related accidents involving ships carrying liquified gasses during the period within the flag states which were considered.

Passenger ships are excluded as they do not conduct cargo operations or cargo related operations.

At the same time, contents of the respective IMO Model courses are not considered in evaluating the training and education received by the seafarers as the IMO Model courses are not compulsory to be complied with.

4. Methodology

Data gathering was carried out with the aid of the GISIS (Global Integrated Shipping Information System) of IMO and publicly available marine accident investigation reports in the websites of the following authorities:

- Bahamas Maritime Authority
- Hong Kong Special Administrative Region Marine Department
- Marine Accident Investigation Branch, UK
- Ministry of Transport, Singapore
- Panama Maritime Authority
- Republic of Cyprus Marine Accident and Incident Investigation Committee
- Republic of Liberia
- Republic of the Marshall Islands Maritime Administrator
- Transport Malta

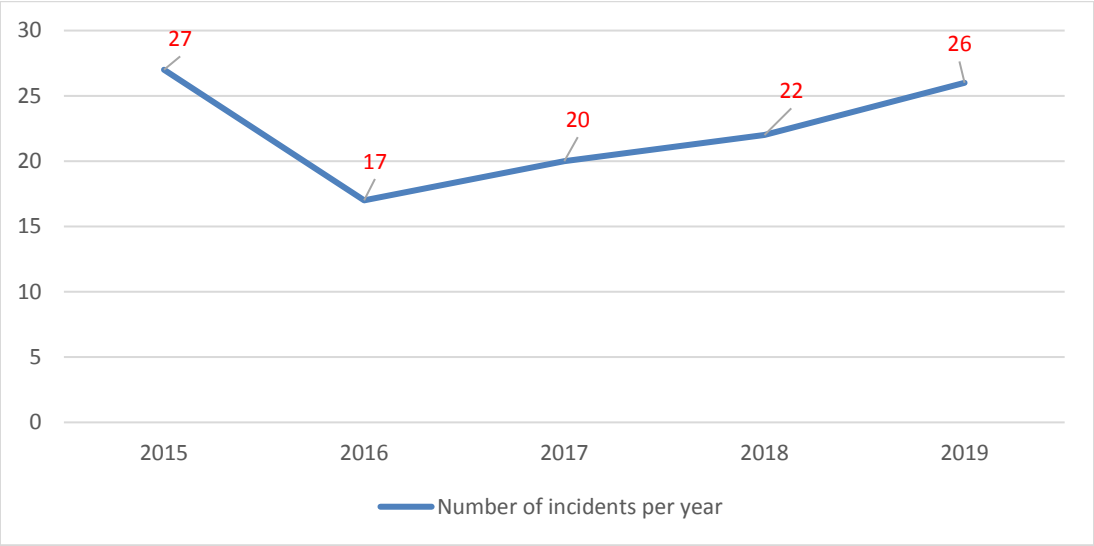
This research is based on accident investigation reports issued by the above Administrations and other Administrations on behalf of the above Administrations with regard to accidents due to cargo related operations.

Data gathering stopped on the 20th of December 2021, which means casualty investigation reports issued after this date have not been accounted for, even though accidents have occurred between 1st January 2015 and 31st December 2019.

It is also worth mentioning here that Casualty Investigation Reports issued by some Administrations are not very informative to conduct an in-depth analysis to identify the causes and the surrounding of the accident to suggest recommendations to eliminate such occurrences in future. That is the reason to select the accident investigation reports published by above nine Administrations in this research.

5. Number of accidents per year

In total there were 440 accidents involving cargo carrying ships of 500 GT and above engaged in international voyages during the period considered. Out of these, 112 accidents were due to cargo related operations. Which means, 25.6% of the accidents during the five-year period among the above nine Administrations were due to cargo related operations.



Total number of cargo related accidents per year

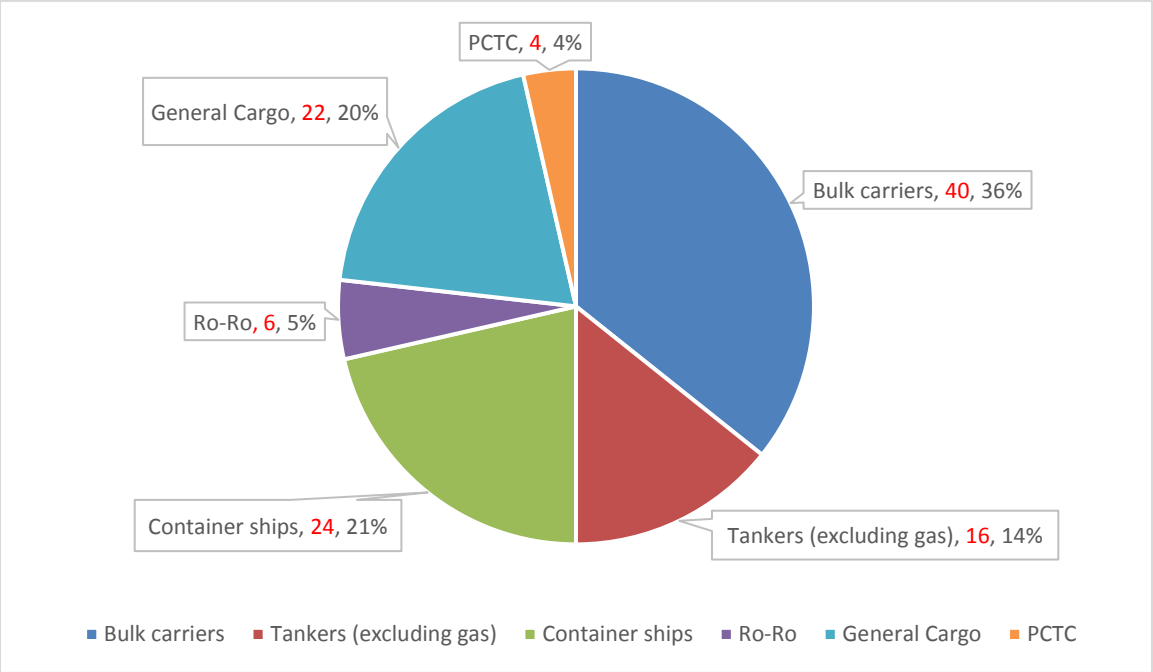
Graph – 1

Carrying out accident investigations and making the reports publicly available may take considerable time. This can be evidenced when referring to the date of the accident and the date of publishing of the report. Which means there could be more accidents which had occurred during the 5-year period but were under investigation and therefore, the reports were yet to be published. Therefore, there is a high possibility that the figures mentioned here could be lesser than the actual figures.

With the available figures we may assume that in an average, 22 cargo related accidents had occurred annually. Even though there is no connection between the number of accidents and the year, when the safety, financial losses and delays are considered, this is a considerable number.

6. Types of ships involved

The percentages shown in the graph below are derived out of total 112 cargo related accidents and the number in red refers to number of cargo related accidents. Tankers include both oil and chemical tankers.



Number of accidents on different types of ships

Graph – 2

During the five-year period, most of the cargo related accidents had occurred onboard bulk carriers. A research involving 18 accident investigation authorities E. Çakır & S. Paker [4] also state that the highest frequency of occupational accidents was found on bulk carriers. But, in their research, occupational accidents include accidents which occurred during cargo related operations, maintenances onboard, mooring, drills etc. When considering the cargo related operations alone, still the highest number of occupational and other accidents had taken place onboard bulk carriers.

This may have a connection with the number of ships as well. Which means, that the number of accidents onboard bulk carriers could increase if the number of the bulk carriers registered withing the above 09 Administrations are higher than the other types of ships.

On the other hand, this could happen due to the continuous change of the type of cargo carried onboard as well. On bulk carriers the situation keeps changing depending on the type of the cargo as the handling procedures, stowing procedures, lashing methods and the safety

precautions to be followed may change from voyage to voyage. Sometimes, the master and the chief officer may have to handle cargo that they have never carried before. This requires a higher competency and knowledge. At the same time due to the change of circumstances, the situational awareness required onboard bulk carriers could be higher than that of the other types of ships. The same is also applicable onboard general cargo ships as well.

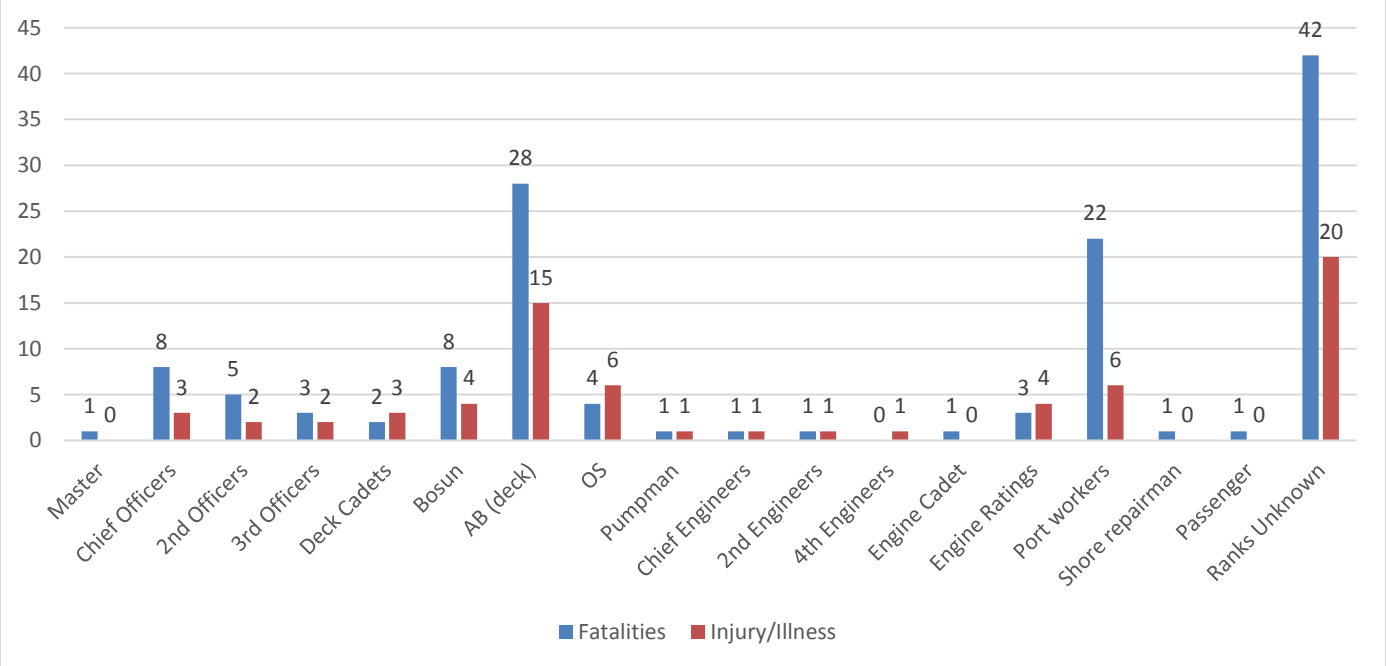
It is interesting to note that no cargo related accidents were reported on gas tankers during this five-year period. But it is not very clear whether the number of gas tanker incidents are zero because:

- there were no gas tankers registered under these flags
- the number of gas tankers registered under these Administrations were less
- the training required to work onboard gas tankers are sufficient
- better safety cultures are implemented on gas tankers

7. Ranks of the persons encountered with injuries and deaths

To reduce the complication of the Graph – 3 (below), some ranks which were mentioned in accident investigation reports are merged as below:

- Chief officers include one 'Apprentice Mate'. It was not very clear about the certification of the Apprentice Mate, but because of the name 'Apprentice Mate', he is included in the Chief officer's category.
- Engine ratings include oilers, motormen and engine fitters.
- Deck cadets include deck cadets and one AO (Apprentice Officer). It was not very clear about the certification of the AO, but because of the name 'Apprentice Officer', he is included in the Deck Cadet's category.
- AB (deck) include:
  - 02 carpenters (certified as Able seafarer deck) and
  - 01 painter (well experienced with deck work)
- Port workers include:
  - 22 stevedores
  - 01 crane operator
  - 01 signalman
  - 01 cargo inspector
  - 01 supervisor
  - 01 foreman and
  - 01 tallyman



Ranks involved with injuries and fatalities

Graph – 3

In the above graph, 'Ranks Unknown' includes:

- four injuries that took place onboard two chemical tankers in two separate incidents
- poisoning due to cargo fumigation of 15 persons (not fatal) onboard a general cargo ship
- one accident took place onboard a container ship making 05 seafarers missing/fatally injured during a fire and the subsequent abandonment of the vessel
- one accident took place on a general cargo ship fatally injuring one crew member and non-fatally injuring another crew member
- 03 bulk carrier losses due to suspected liquefaction/shift of cargo making 36 persons missing.

The fatalities and injuries mentioned in the above Graph – 3 had taken place during 94 accidents which occurred onboard 94 ships. Apart from these 94 occupational accidents there were 18 accidents which only caused material damages (cargo or ship damages) without any injuries.

Therefore, due to the 112 accidents, in total there were:

- 132 fatalities/missing
- 69 injuries and
- 18 cargo/ship damages without injuries

01 master, 23 deck officers and 67 deck ratings were injured fatally/nonfatally during the period excluding the deck cadets. When considering the total overall occupational accidents onboard ships, Erkan [6] states that there is a significant difference by occupation on board; ratings had significantly higher fatal injury rates compared to officers. That is because the number of occasions the ratings are exposed to occupational accidents and the number of ratings exposed to occupational accidents at any given time is higher than that of the deck officers.

7.1 Deck officers and deck cadets

It was a little embarrassing to note that 01 master and 16 deck officers were fatally injured and 7 were less seriously injured after achieving the competencies and KUP as required by the STCW Code.

The number of deck cadets involved were less probably because:

a) only few ship owners employee deck cadets
b) if employed, usually only one deck cadet will be employed on one ship
c) most of the companies do not allow the cadets to work unsupervised and
d) experienced seafarers take care of deck cadets as they are inexperienced

The present competencies that are required to be gained by deck officers are discussed in detail under different chapters below.

7.2 Bosuns

Eight bosuns were fatally injured and four were less seriously injured during this period. There are no special training and certification requirements provided in the STCW Code to become a bosun. But bosuns are front line players of not only cargo related operations but also other operations in the deck department. The norm of the industry is to promote an experienced and competent AB (deck) as a bosun. The suitability of an AB (deck) for the promotion is decided by the company depending on the reports of the masters and chief officers that he has worked with.

Bosuns are required to have very good proficiency on deck and cargo related operations. Because they are the persons who handle, supervise and monitor other deck ratings under the guidance of the chief officer.

7.3 Able seafarer (AB) deck

In total 43 AB (deck) were injured/killed during 35 accidents. Which means the number of AB (deck) involved in accidents are comparatively high. The most possible causes for this are:

a) Normally a ship has three AB (deck) and other than during cargo loading / discharging operations there could be at least two ABs (deck) carrying out cargo related activities during daytime at sea and at anchorages. Therefore, the number of AB (deck) exposed to risk is higher.
b) The frequency of exposure to risk is higher than others since the AB (deck) are involved with cargo related activities more frequently than others.

Therefore, there is a higher risk of AB (deck) getting injured during cargo related operations.

International Labour Organization (ILO) states that the training and certification in accordance with the mandatory instruments adopted by the International Maritime Organization shall be considered [7] with regards to seafarer training and certification. Other than that, the MLC 2006 (Maritime Labour Convention 2006) does not specify any areas to be trained for different ranks onboard ships.

IMO made the certification for AB (deck) mandatory for the parties of the STCW Convention through 2010 amendments to the Convention (famously called as Manila amendments) which also includes the areas that should be proficient by an AB (deck) prior to certification. Manila amendments were implemented on 1st January 2017, making the Certificate of Proficiency (COP) as Able seafarer (deck) compulsory to sail as AB (deck). Concurrently, all the countries subjected to this research made the COP as AB (deck) compulsory from 1st January 2017, except the United Kingdom. For the United Kingdom, the COP for AB (deck) became mandatory from

9th June 2015 [8]. Therefore, the professional knowledge of the AB (deck) other than on the British flagged vessels cannot be evaluated until after 1st January 2017.

Table A-II/5 of the STCW Code provides the areas that a seafarer should be trained and proficient prior to obtaining the COP as AB (deck). According to the Table, with regards to cargo handling and stowage AB (deck) should have KUP in:

- *knowledge of procedures for safe handling, stowage and securing of cargoes and stores, including dangerous, hazardous and harmful substances and liquids*
- *basic knowledge of and precautions to observe in connection with particular types of cargo and identification of IMDG labelling*

To gain the above KUP an approved programme is not required to be followed by the seafarers having 18 months or more sea time after obtaining the certificate of proficiency as rating forming part of a navigational watch [9].

At the same time, experienced seafarers who were sailing as AB (deck) prior to implementing the Manila amendments received their AB (deck) certificate without following an approved training programme because the Regulation A-II/5 of the STCW Code states that an Administration can issue AB (deck) certificate for seafarers who have served in a relevant capacity in the deck department for a period of not less than 12 months within the last 60 months preceding the entry into force.

Because of the above two reasons:

- efficiency of following the approved programme in accordance with the Table A-II/5 cannot be evaluated and
- the professional knowledge they had in cargo related matters cannot be evaluated other than the tanker ABs as they are required to undergo training on basic oil and chemical tanker cargo operations.

Probably, the AB's (on other than tankers) professional knowledge related to cargo matters were limited to the knowledge that they gained from the Personal Safety and Social Responsibilities (PSSR) programme as required by the STCW Code and the knowledge gained by experience.

7.4 Ordinary seamen (OS)

Usually, the OS are also looked after by the senior personnel and experienced staff as they do not have much experience and most companies do not allow the OS to work unsupervised. But, sometimes there were OS with 2-3 year sea going experience. This may lead the OS to work unsupervised. Because it is interesting to note that out of the total 10 OS injured/deceased only

one OS was found with minimal sea experience. Seven OS had sufficient sea time and in two cases there was insufficient information to check the experience.

Out of these ten incidents, 05 were on tankers, four on bulk carriers and one incident took place on a Ro-Ro vessel.

All of the above OS were having Certificates of Proficiency in basic training and most of them were having Certificate of Proficiency as rating forming part of a navigational watch as well. No special cargo operations related training is required by STCW Code to sail as an OS or as a rating part of a navigational watch. Cargo operations related training is included only in the PSSR training programme. In accordance with the Table A-VI/1-4 of the STCW Code, the cargo related competency that a candidate is required to achieve in PSSR training programme is '*Observe safe working practices*'. In achieving this competency, the KUP they are required to gain includes:

- *Importance of adhering to safe working practices at all times*
- *Safety and protective devices available to protect against potential hazards aboard ship*
- *Precautions to be taken prior to entering enclosed spaces*
- *Familiarization with international measures concerning accident prevention and occupational health*

Above KUP covers a wide area of safe working practices onboard ships. But, the duration of the PSSR programme depends upon the Administrations of the individual countries. In accordance with the information available on the websites, the duration of the PSSR programme varies from 1-4 days. Which means, some holders of PSSR certificates have only a very basic knowledge on the risks involved with cargo related operations, even though the above KUP covers a wide area, except for those who are working on tankers.

To work onboard tankers as AB (deck) or OS it is required to have Certificate of Proficiency in basic training for oil and chemical tanker cargo operations. Table A-V/1-1-1 of the STCW Code provides areas to be covered during the basic training for oil and chemical tanker cargo operations.

7.5 Pumpmen

During this 5 year period, one pumpman was fatally injured while another one sustained minor injuries. There are no special certificates required by the STCW Code to sail as a pumpman. Certificates that they are required to obtain related to cargo matters include:

- Certificate of Proficiency in personal safety and social responsibilities and
- Certificate of Proficiency in basic training for oil and chemical tanker cargo operations

These are the same certificates held by OS on tankers. But, the number of incidents involving pumpmen are less may be because:

- only one pumpman is employed onboard
- some shipowners may not employ pumpmen
- they are usually much more experienced than OS and AB (deck)
- they undergo company specific various training programmes

Pumpmen onboard tankers are assigned demanding duties [10] but, STCW Code does not require any special certification for them.

7.6 Engineering officers and engineering ratings

This is not analysed because it is beyond the scope of this research and these accidents could have been avoided if the deck officers and deck ratings were competent enough.

7.7 Port workers

There were 22 fatal injuries and 06 non-fatal injuries in total during the period. Even though this is also out of the scope of this research, it is worth discussing at least to a certain extent as port workers are also directly involved with cargo related operations rather than engineer officers and engine ratings.

8. Categorization of accidents

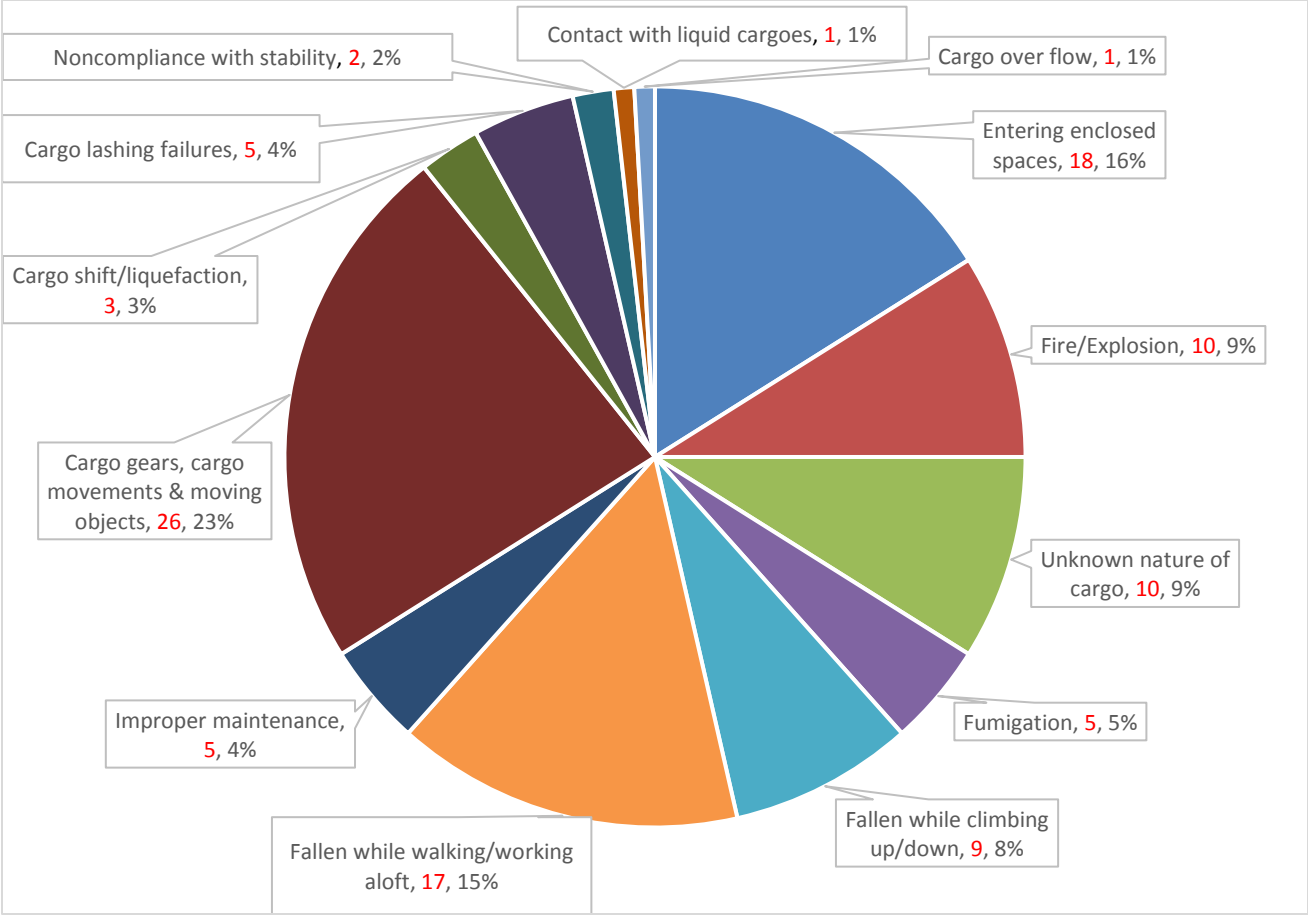
All the cargo related, or cargo operations related accidents incurred during the said 5-year period are categorized as accidents due to:

- Entering enclosed spaces
- Fire/explosion
- Unknown nature of cargo
- Fumigation (of cargoes)
- Fallen while climbing up/down (vertical ladders)
- Fallen while walking/working aloft (working aloft means ‘working at height’ where a person could fall a distance liable to result in an injury to them [11])
- Improper maintenance
- Cargo gears, cargo movements and moving objects
- Cargo shift/liquefaction
- Cargo lashing failures/improper lashing (during rough weather)
- Noncompliance with stability criteria
- Contact with liquid cargoes
- Cargo overflow

Categorization of all the types of the above accidents are self-explanatory except the accidents due to ‘cargo gears, cargo movements and moving objects’. This category of accidents include:

- Run over by vehicles onboard Ro-Ro ships
- Accidental hits by pontoons, cargo slings or similar material
- Falling of containers or container securing materials
- Accidental hits by lashing material and
- Similar accidents

Following graph illustrates the number of accidents (in red) and percentages of types of accidents incurred onboard all types of ships. The percentages were calculated out of a total of 112 cargo related accidents.

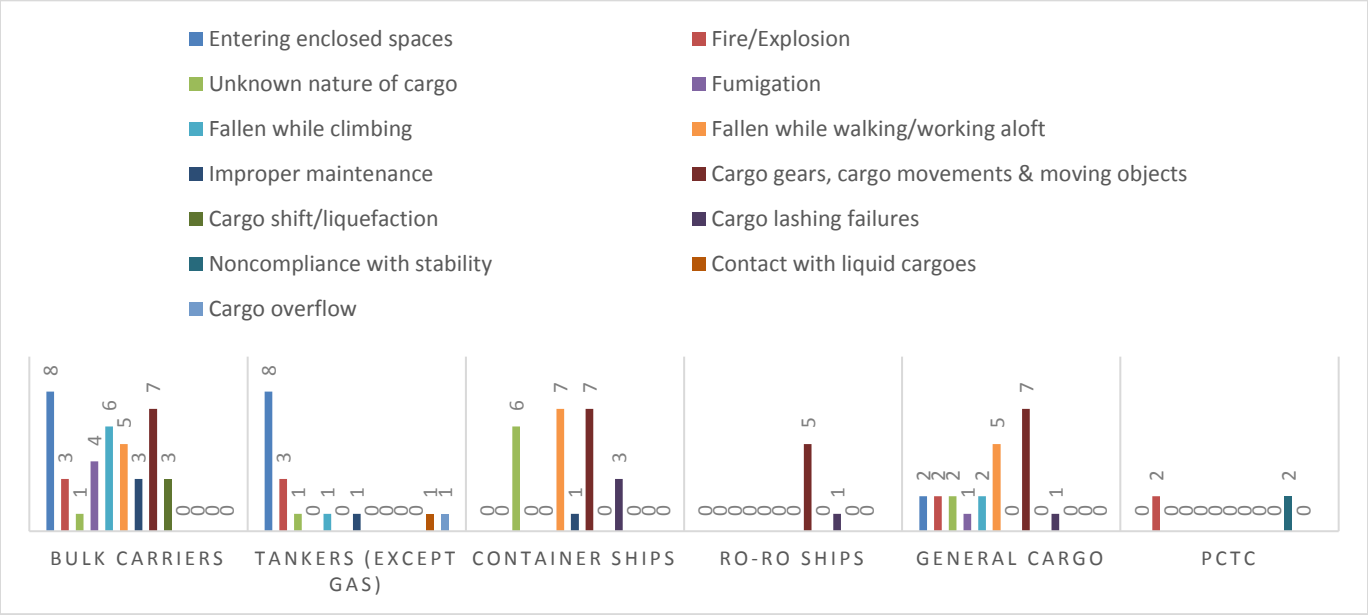


Types of accidents

Graph – 4

The number of accidents due to cargo gears, cargo movements & moving objects are high because of the types of subcategories of the accidents included within it.

9. Number of each type of accident against types of ships



Number of incidents against type of ships

Graph – 5

It is important to note that, most types of the categorized accidents could only occur on bulk carriers and general cargo ships. Certain types of accidents will not occur onboard tankers, container ships and Ro-Ro ships. As an example, accidents due to fumigation may not occur onboard tankers, container ships, Ro-Ro ships and PCTC (Pure Car and Truck Carriers). Therefore, there is a higher risk with regards to cargo operations and cargo related accidents onboard bulk carriers and general cargo ships.

Climbing up/down on fixed ladders inside cargo holds/tanks are common onboard bulk carriers, tankers & general cargo ships since they require frequent hold/tank cleaning before loading the next cargo. But, it is not clear why the number of accidents caused climbing up/down ladders are comparatively less onboard tankers while accidents caused due to entering enclosed spaces are high.

9.1 Accidents onboard bulk carriers

Most types of the accidents (09 out of the 13 types of categorized accidents) have taken place onboard bulk carriers, except for the accidents caused by:

a) Cargo lashing failures/improper lashing
b) Noncompliance with stability criteria
c) Contact with liquid cargoes
d) Cargo overflow

At the same time, the highest number of accidents (40 accidents) have taken place onboard bulk carriers as discussed along with the Graph – 2 above.

This shows that higher competencies and situational awareness is required onboard bulk carriers due to the continuous change of type of cargo carried and change of operational requirements. Onboard bulk carriers the highest number of accidents have taken place due to:

a) Entering enclosed spaces
b) Cargo gears, cargo movements and moving objects
c) Fallen while climbing up/down
d) Fallen while walking/working aloft
e) Fumigation

Even though the number and the types of accidents onboard bulk and general cargo vessels are high no special cargo related certifications are required as needed to sail on tankers.

Onboard geared bulk carriers, there are various types of cargo gears such as cranes, derricks, grabs, conveyor belts etc. These are operated by seafarers for various cargo related operations.

On some bulk carriers, there are tween decks as well, which are required to be closed and opened depending upon the types of cargoes carried.

Therefore, onboard bulk carriers there are comparatively more complicated cargo related operations that are required to be carried out by deck ratings and deck officers which require good situational awareness, knowledge and competency.

9.2 Accidents onboard tankers

Types of accidents incurred onboard tankers are comparatively less than on bulk carriers. Only 07 types of accidents out of the 13 types of categorized accidents had taken place onboard tankers. The reasons for this could be because of:

- the higher safety cultures implemented by the companies and the tanker industry
- the legislations adopted by IMO, flag states and port states
- higher cargo related competencies and KUP achieved by seafarers
- following types of accidents may not happen on tankers:
    - accidents due to fumigation
    - accidents due to cargo gears, cargo movements and moving objects
    - cargo shift/liquefaction
    - accidents due to cargo lashing failures/improper lashing

On tankers the highest number of accidents were taken place during enclosed space entries because frequent tank entries are required for tank cleaning purposes to avoid cargo contamination and the second highest type of accident is due to fire/explosion.

Onboard tankers, the cargo gears, the pumps are mainly handled by chief officer and sometimes by the second officer. Like on bulk carriers the ratings are not involved with cargo gears related operations on tankers.

9.3 Accidents onboard container ships

05 out of the 13 categorized accidents had taken place onboard container ships. At the same time, second highest number of accidents (21% of the accidents) had taken place onboard these ships, which was also elaborated along with the Graph – 2 above. On container ships the highest number of accidents were taken place due to:

a) Falling while walking/working aloft
b) Cargo gears, cargo movements and moving objects
c) Unknown nature of cargo (fires onboard due to undeclared nature of cargo)

Types of accidents incurred onboard container ships were lesser than bulk carriers and general cargo ships may be because:

- less cargo related operations carried out at sea other than daily checking of the container lashings
- less enclosed space entries for cargo related operations
- cargo related precautions to be observed does not change frequently
- at the same time, following types of accidents may not occur onboard container ships:
  - accidents due to fumigation
  - accidents due to cargo shift/liquefaction

Ratings and the deck officers are required to handle cargo gears while opening & closing cargo holds (when hydraulically operated pontoons are not fitted), securing them for sea and when making them ready for stevedores to start cargo operations. But on container ships, the complexity of cargo gears related operations are lesser than on bulk carriers and general cargo gears.

9.4 Accidents onboard Ro-Ro ships

The main type of accident that had occurred onboard Ro-Ro ships was accidents due to cargo gears, cargo movements and moving objects while loading or discharging operations. In fact,

five accidents had taken place due to being run over by vehicles during cargo operations and one accident took place due to improper lashing.

Only two types of the categorized accidents had taken place onboard these types of ships. The number of Ro-Ro ships involved in accidents were less probably because:

- the number of Ro-Ro ships registered under these flags may be lesser than the bulk carriers, tankers and container ships.
- better safety cultures implemented onboard as they are carrying passengers as well
- less cargo related operations are carried out onboard other than parking and lashing the vehicles
- less enclosed space entries for cargo related operations
- cargo related precautions which need to be observed do not change frequently
- following types of accidents will not occur onboard Ro-Ro ships:
    - unknown nature of cargo,
    - fumigation,
    - cargo shift/liquefaction
    - contact with liquid cargoes and
    - cargo overflow

Onboard Ro-Ro ships the cargo gears related equipment include internal ramps, external ramps, bow doors etc. Again, would say complexity of cargo gear operations on board Ro-Ro ships are lesser than onboard bulk carriers and general cargo ships.

9.5 Accidents onboard general cargo ships

The second highest number of categorized types of accidents (08 out of the 13 types of accidents) have taken place onboard general cargo ships. The third highest number of accidents (20% accidents) have taken place onboard these ships, which was also elaborated along with the Graph – 2 above.

Most of the accidents onboard the general cargo ships have taken place because of the cargo gears, cargo movements and moving objects. As the working environment keeps changing with the type of cargo carried, good situational awareness is required onboard general cargo ships as well.

Same as the bulk carriers, the complexity of cargo gear related operations exists with general cargo ships as well which needs good situational awareness, knowledge and proficiency.

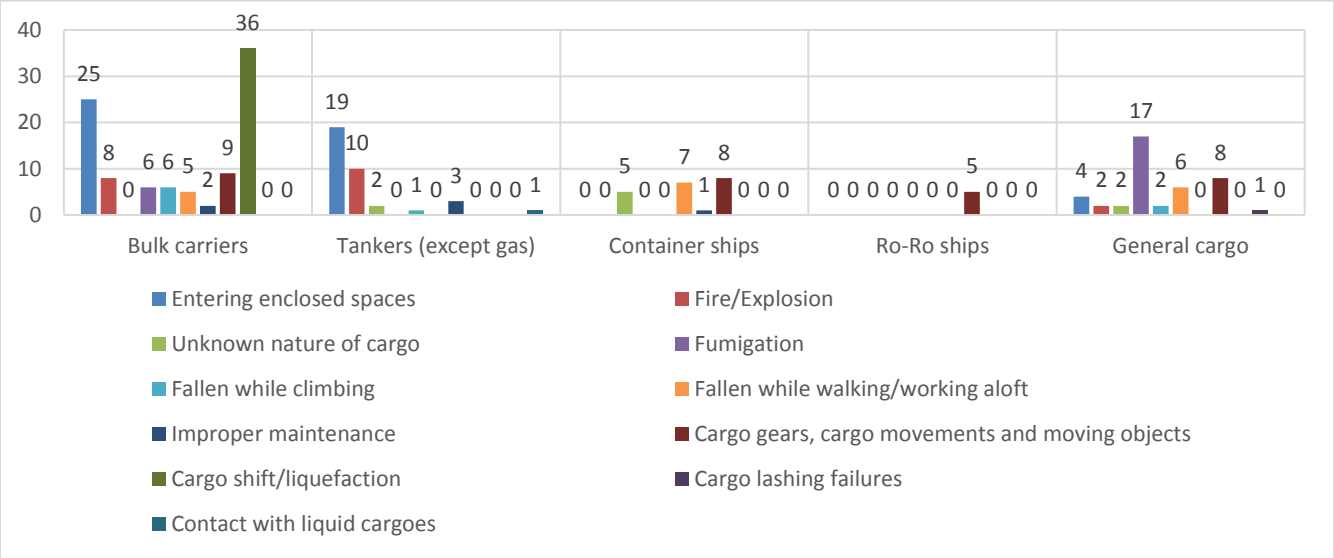
9.6 Accidents onboard PCTC

Accidents onboard PCTCs were limited to noncompliance with stability criteria and cargo fires. The reasons to have lesser number of accidents onboard PCTCs could be due to:

- Lesser number of PCTCs registered
- Cargo related precautions to be observed does not change frequently
- Following types of accidents are not applicable for PCTCs:
    - Unknown nature of cargo
    - Fumigation
    - Cargo shift/liquefaction
    - Contact with liquid cargoes
    - Cargo overflow

Onboard PCTC the cargo gears related equipment includes internal ramps, external ramps, movable decks and deck lifters. Change of circumstances may not occur same as bulk carriers and general cargo ships.

10. Number of people injured/died against the type of accident and the type of ship



Number of people injured/died against type of ship and type of accident
Graph – 6

PCTCs are excluded from the above graph as all the seafarers onboard the vessels were evacuated safely after the accidents.

10.1 Cargo gears, cargo movements & moving objects

Highest number of accidents had occurred due to cargo gears, cargo movements and moving objects which amounted to 23% (26 accidents out of 112 accidents) of the total accidents. 30 people were injured / died due to these 26 accidents.

On bulk carriers 07 incidents *(Graph – 05 above)* have taken place causing 09 injuries/deaths as below:

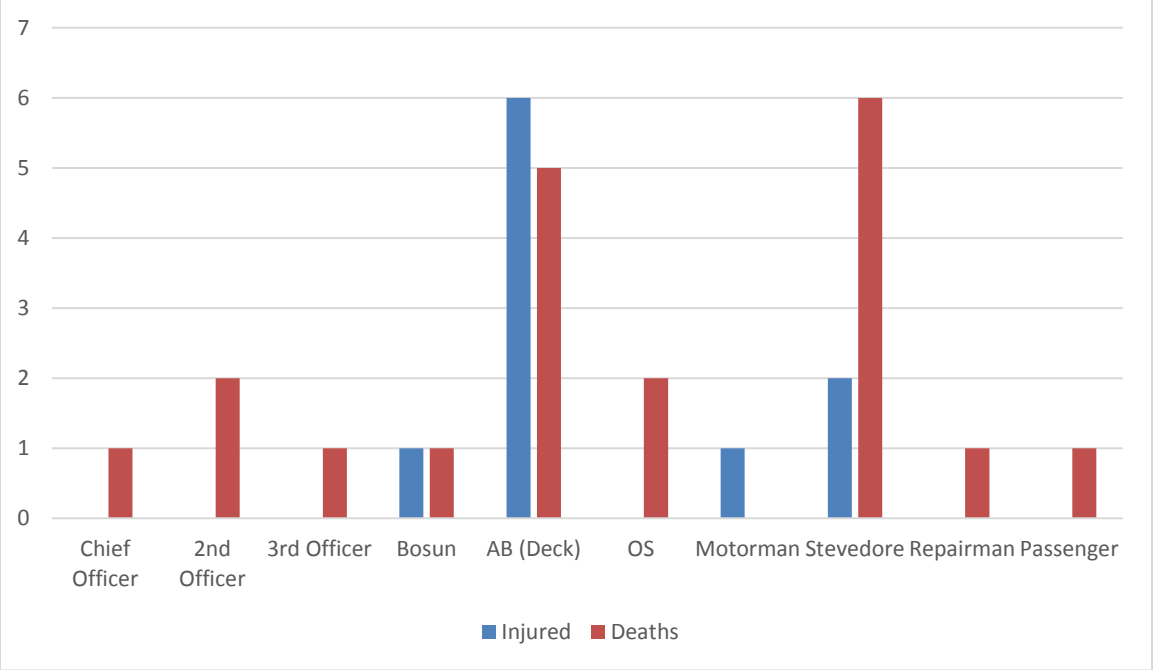
- Two AB (deck) and one port worker died due to mishandling of ship's cargo gears during three incidents.
- One OS died due to portable davit failure while heaving up cargo residues from a hold.
- 01 AB (deck) was injured, and 01 AB (deck) died due to a lashing wire failure while lashing logs.
- One port worker died due to being run over by a bulldozer inside a cargo hold.
- 01 port worker died and one injured due to a bulk cargo collapse inside a hold.

On container ships 08 people were injured/died during 07 accidents *(Graph – 05 above)* as below:

- A container was loaded on a signalman fatally injuring him
- A lashing bar fell on the foot of an AB injuring his foot while he was not wearing the safety shoes properly
- In the same incident, bosun was injured and an AB was crushed between two containers fatally injuring him
- A port worker was crushed between two containers fatally injuring him due to a spreader failure
- A shore repairman was hit against a spreader, fatally injuring him while inside a cargo hold
- In two incidents one 2nd officer and one port worker died due to falling of twist locks.

On Ro-Ro ships 05 accidents had taken place due to cargo gears, cargo movements and moving objects causing 04 deaths and 01 injury. All of them were due to being run over by vehicles during cargo operations. Out of these five, in three occasions the seafarer who was signalling the driver to park the vehicle was seriously or fatally injured by the same vehicle. In the other two incidents, the duty officer was run over by a discharging vehicle while he was talking on his mobile phone and a disoriented passenger was run over by a vehicle fatally injuring them.

Following ranks were injured and deceased due to the total of 26 accidents occurred on all types of ships:



Ranks of injured & dead seafarers due to cargo gears, cargo movements & moving objects

Graph – 7

In total there were 7 accidents involving 'cargo gears' alone, during the five year period as described below:

- On two general cargo ships, a chief officer and a bosun were fatally injured while trying to re-position (suspected) themselves by using cargo gears.
- On a general cargo vessel, a 2nd officer was crushed between pontoons and ship's gantry crane encountering fatal injuries.
- Two ABs were injured as they were standing within the 'hazardous fall zone around a suspended load [12]' due to a parted sling while it was being heaved up by crane on a general cargo vessel
- On a bulk carrier, an AB (deck) was fatally injured while a crane was used to trim the cargo by dragging a pontoon.
- One port worker died when he was trapped in a grapple when the crane was operated without a signalman on a bulk carrier.
- On a bulk carrier a carpenter (certified as AB (deck)) was thrown overboard due to a swinging cargo hook during moderate weather and was fatally injured.

10.2 Entering enclosed spaces

In the case of entering enclosed spaces, 'injuries' include situations where people have entered the enclosed space and left the compartment after feeling an eye irritation or a dizziness or difficulty in breathing before they became casualties. Because, for the time being even though they have managed to escape from the danger, these sorts of unsafe practices may lead to serious accidents and it shows the competencies and proficiencies of the seafarers, which is required to identify the gaps in the present practices onboard ships.

The second highest type of accident is the accidents caused due to entering enclosed spaces. A total of 18 (16% of the total cargo related) accidents have occurred due to entering enclosed spaces. In fact, this is without the two incidents which occurred by entering fumigated compartments and 01 incident due to entering a cargo hold, loaded with unknown nature of cargo. If these three incidents were also included, accidents involved with enclosed spaces will rise to 19%.

The highest number of accidents due to entering enclosed spaces had taken place onboard bulk carriers and tankers. It is common to enter cargo tanks and cargo holds of tankers and bulk carriers for cleaning purposes after the completion of discharging. On tankers, this type of accidents has caused 09 deaths and 10 injuries *(Graph – 06 above)* during 08 accidents *(Graph – 05 above)*. This is the most common type of accident on tankers as well.

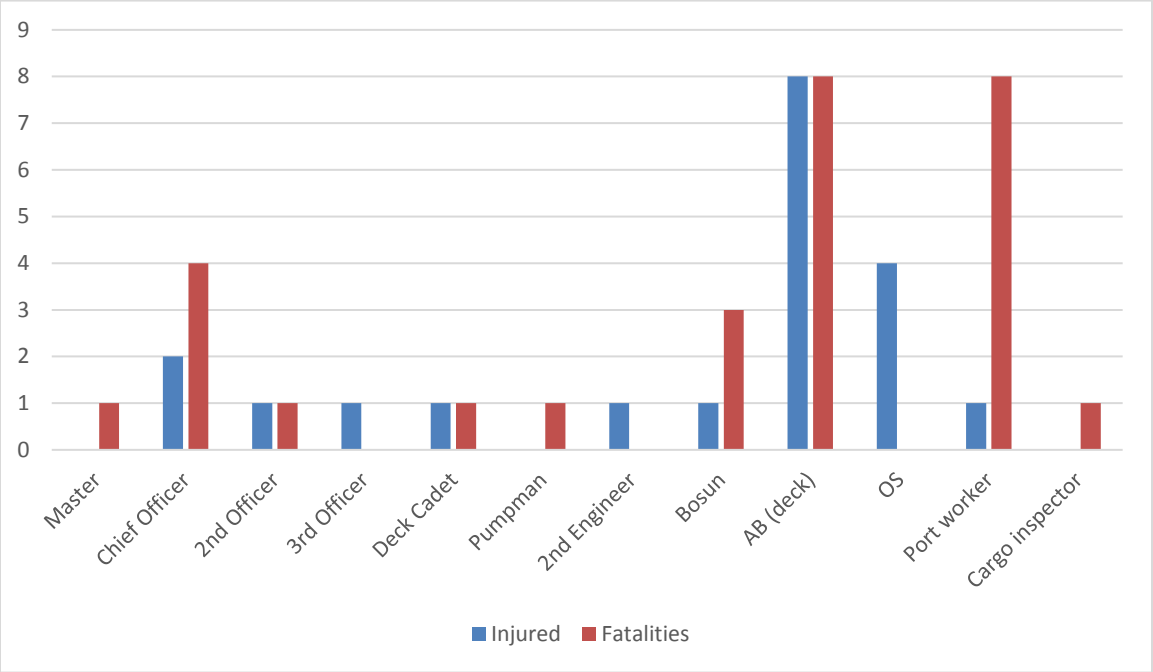
On bulk carriers, 15 deaths and 10 injuries *(Graph – 06 above)* were caused during 08 accidents *(Graph – 05 above)*.

02 incidents have taken place onboard general cargo ships ending with 04 fatalities.

Therefore, in total 48 people had died or were injured during 18 accidents onboard all types of ships due to enclosed space entries. Unlike other types of accidents, accidents involving enclosed spaces may lead to higher number of casualties if the initial incident is not handled properly. It is important to note that:

- Out of the above 18 accidents, only 05 accidents were handled with acceptable emergency handling procedures.
- 23 people were dead/injured due to the initial entry into enclosed spaces without complying with the correct procedures.
- 25 people were dead/injured as they entered enclosed spaces without complying with correct emergency handling procedures to rescue the above 23 people. Which means, 25 people could have avoided deaths/injuries if they had followed the correct emergency handling procedures.

Following ranks were injured and dead due to the total of 18 accidents occurred on all types of ships:



Ranks injured & died in entering enclosed spaces

Graph - 8

It is quite amazing to see, how the deck officers have also become casualties of entering enclosed spaces even after receiving extensive theoretical knowledge and adequate sea time.

Revised recommendations for entering enclosed spaces aboard ships [13] was adopted on 30th November 2011, but still accidents involving entering enclosed spaces is a major problem in the shipping sector.

STCW'78 as amended requires the deck officers and the deck ratings to be trained on entering enclosed spaces during couple of training programmes as below:

- Table A-II/5 : AB deck
- Table A-V/1-1-1 : Basic training for oil & chemical tanker cargo operations
- Table A-V/1-1-2 : Advanced training for oil tanker cargo operations
- Table A-V/1-1-3 : Advanced training for chemical tanker cargo operations
- Table A-V/1-2-1 : Basic training for liquefied gas tanker cargo operations
- Table A-V/1-2-2 : Advanced training for liquified gas tanker cargo operations
- Table A-VI/1-4 : Personal safety and social responsibilities (PSSR)

Above mentioned 18 accidents which occurred due to entering enclosed spaces were only related to cargo operations but there were considerable number of accidents involving entering enclosed spaces during maintenances onboard ships as well during the 5 year period considered.

When considering the total number of accidents involving enclosed spaces (accidents took place during maintenances and cargo related operations) there is a high possibility that there could have been further occasions onboard all types of ships where people have entered enclosed spaces without complying with the safety procedures, but operations were completed without any accidents. As an example, entering an enclosed space without testing the Oxygen content in the space, but managing to complete the operation without any accident due to having a sufficient level of Oxygen purely based on luck. Therefore, this is something to be addressed immediately.

Most importantly, unlike in other accidents, in the case of enclosed space entries, the number of casualties would be increased further, if the onboard staff were not trained properly in handling the emergency as pointed out above.

10.3 Fallen while walking/working aloft

During the five-year period there were 18 fatalities/injuries *(Graph – 06 above)* which occurred due to 17 accidents *(Graph – 05 above)* which resulted in falling while walking/working aloft.

Following 07 accidents took place on container ships due to walking/working aloft:

- Carpenter (certified as AB) fell into a cargo hold while walking on a catwalk
- One 2nd officer was fatally injured by falling on to the jetty while trying to close a ventilator while standing on a pontoon
- Another 2nd officer had fallen overboard and gone missing while engaged in unlashing of containers during the passage of the vessel
- A chief officer was fatally injured by falling down while taking photographs inside a cargo hold
- In two different incidents, two port workers died after falling down to cargo holds
- An AB fell inside a hold while working on a pontoon

Following 05 accidents occurred on board bulk carriers:

- A bosun fell and was fatally injured while walking/working on timber deck cargo
- An AB fell from a portable ladder and was fatally injured while engaged in hold cleaning
- A deck cadet was fatally injured after falling while engaged in securing of timber deck cargo
- A chief officer fell inside a cargo hold and was fatally injured due to entangling with a messenger rope while engage in cargo hold cleaning operations
- An AB fell into a cargo hold while working on a pontoon and fatally injured

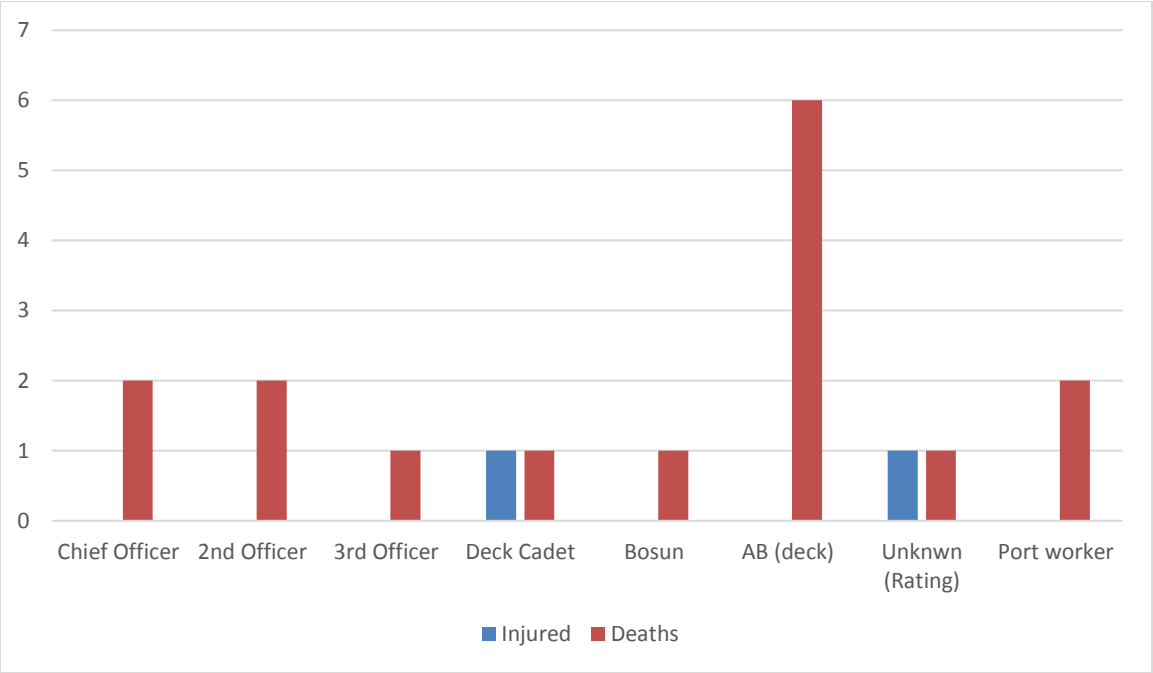
Following 05 accidents took place onboard general cargo ships due to walking/working aloft

- In two incidents, two ABs fell down and were fatally injured while engaged in hold opening/closing operations.
- A 3rd officer was fatally injured by falling into a lower hold while engaged in cleaning tween deck.
- One crew member was fatally injured and another was non fatally injured (ranks unknown) while engaged in cargo hold opening.
- A deck cadet was fatally injured after falling into a hold while walking on pontoons of a partly opened cargo hold.

Even though it is not within the scope of this research, it is worth mentioning that this type of accidents had occurred not only during cargo related operations, but during maintenance operations as well.

There were no such accidents onboard tankers, Ro-Ro and PCTC during the five year period.

Following ranks were injured and had died due to the total of 17 accidents occurred on all types of ships:



Ranks injured & died due to falling while walking/working aloft

Graph - 9

10.4 Fallen while climbing up/down

There were 09 accidents *(Graph – 05 above)* due to falling while climbing up/down which had caused 09 fatalities *(Graph – 06 above)*.

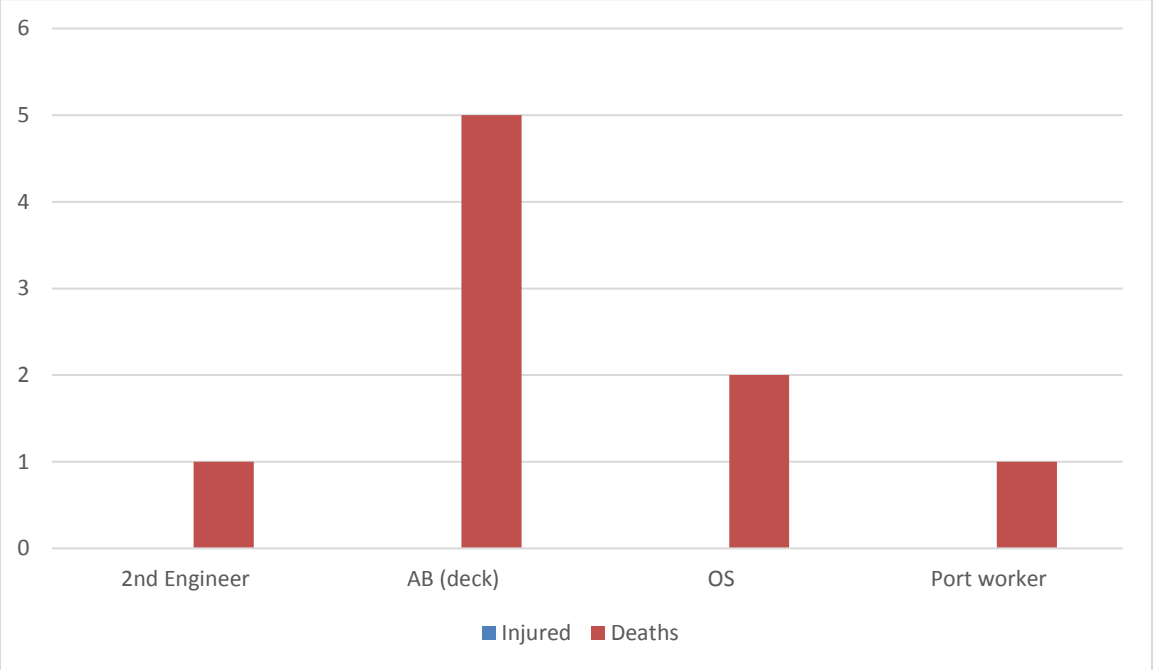
Most of the accidents related to falling while climbing has taken place onboard bulk carriers. 06 fatalities have occurred during 06 accidents. These include one 2nd engineer while climbing down the hold to clean it. It was little surprising to note that on this ship even the engineering officers have been engaged in hold cleaning operations. On bulk carriers it is very common to climb up & down ladders very frequently for the purposes of hold cleaning.

Two similar accidents had taken place on board general cargo ships causing two fatalities.

One fatality took place onboard a tanker due to the same type of accident.

There were no similar accidents onboard containers ships, Ro-Ro and PCTC probably because it is not a common practice to climb up and down vertical ladders onboard these types of ships other than for routine maintenance purposes.

Following ranks were injured and had died due to the total of 09 accidents which occurred on all types of ships:



Ranks injured & died due to falling while climbing up/down

Graph – 10

10.5 Unknown nature of cargo

During the 5 year period there were 10 accidents *(Graph – 05 above)* due to unknown nature of cargo causing 06 fatalities, 03 injuries and 06 accidents without injuries. These accidents took place as below:

- Fire occurred onboard a bulk carrier without injuries
- An explosion took place on a chemical tanker injuring two persons
- Fires occurred onboard 5 container ships without injuries
- Another fire took place on a container vessel causing 05 fatalities/missing with subsequent abandonment of the vessel
- One chief engineer lost his life after entering a cargo hold loaded with unknown nature of cargo on a general cargo ship

- Another chief engineer sustained injuries caused by an explosion while carrying out maintenance work in the forward of the vessel while cargo was loaded onboard a general cargo ship

The accidents which took place onboard the bulk carrier and the 1st general cargo vessels were due to lack of information on the International Maritime Solid Bulk Cargoes Code (IMSBC Code) and the accident which took place onboard the chemical tanker was due to lack of information on the International Code for the Construction and Equipment of ships carrying Dangerous Chemicals in Bulk Code (IBC Code) which are beyond the control of the seafarers onboard.

The explosion on the second general cargo vessel took place while she was loaded with a cargo in bulk which is not listed in the IMSBC Code. In accordance with the amendments made to the IMSBC Code, when a cargo which is not listed in the Code is intended to be carried in bulk, the competent authority of the port of loading should provide to the master, a certificate stating the characteristics of the cargo and the required conditions for carriage and handling of that shipment [14] and this became mandatory from 1st January 2015. This accident took place in 2017 and could have been avoided if the master or the chief officer was aware of the contents of the IMSBC Code with regards to the carriage of goods in bulk which were not listed in the Code.

The highest number of accidents (6 accidents in total) were due to the unknown nature of cargo has happened onboard container ships. These accidents were due to:

- undeclared International Maritime Dangerous Goods (IMDG) cargoes or
- cargoes which were not identified as a dangerous good by the IMDG Code or
- lack of information with regards to nature of the cargo in the IMDG Code

10.6 Fumigation

05 accidents *(Graph – 05 above)* had occurred due to fumigation causing 05 deaths, 18 injuries *(Graph – 06 above)* and one explosion (without casualties) as below:

- Bulk carriers - 04 incidents have taken place onboard bulk carriers causing 03 fatalities (including one port worker, 01 engine cadet and a bosun), 03 injuries (port workers) and one explosion without injuries. The port worker and the bosun died after entering a fumigated cargo hold and the engine cadet died because of fumigants leaking into the accommodation. Three port workers were injured while trying to rescue the above fatally injured port worker.
- General cargo ship – one incident took place onboard a general cargo ship causing 02 fatalities and 15 injuries due to fumigants leaking into the accommodation.

It is important to note that another accident caused due to fumigant leaking into the accommodation had taken place during the year 2020 as well causing one fatality and three crew injuries within the flag states considered in this research. This accident is not included in this research as it is beyond the scope.

10.7 Fire/explosion

There were 10 accidents *(Graph – 05 above)* causing 07 deaths and 13 injuries *(Graph – 06 above)* in total. In fact, there were:

- another 09 fires/explosions which were categorized under 'unknown nature' of cargo,
- one explosion due to 'improper maintenance' and
- one explosion due to 'fumigation' which are not included in this category of accident.

Three accidents have taken place on bulk carriers which caused four deaths and four injuries as follows:

- One fitter was fatally injured, and two others received minor injuries due to an explosion while carrying out welding work on a hatch coaming of a cargo hold loaded with coal
- One port worker had received fatal injuries while in a cargo hold loaded with coal where the cause of the fire was unknown.
- One explosion took place onboard a bulk carrier loaded with coal while trying to open a void space injuring an OS & Chief Officer (Apprentice Mate) and fatally injuring one AB (deck) & a bosun.

Three accidents took place on tankers causing two fatalities and 08 injuries as detailed below:

- One died and 05 were injured due to an explosion while carrying out tank cleaning operations when two known incompatible cargoes were mixed accidently.
- One died and one was injured due to a fire and the subsequent explosion while preparing for tank cleaning.
- Two injuries took place while carrying out gas freeing and tank cleaning operations.

Two PCTC caught fire while carrying used vehicles due to fires occurred on used cars without injuries or fatalities.

Two fires/explosions took place onboard general cargo ships as below:

- An explosion took place injuring one oiler and fatally injuring another while trying to light a cigarette in a forward store when the vessel was loaded with coal.
- One fire took place due to noncompliance with the requirements of the IMSBC Code, without causing any injuries.

10.8 Improper maintenance

There were 05 accidents *(Graph – 05 above)* in total due to improper maintenances causing 04 deaths, two injuries and 01 crane damage.

Most of the accidents due to improper maintenances had taken place onboard bulk carriers. These include 03 accidents which ended up with two fatalities and one crane damage (without injuries) as detailed below:

- While an AB was going down to a hold, he fell into the hold after stepping on to an improperly secured greting sustaining fatal injuries
- A port worker had fallen into a cargo hold due to a cargo access cover failure receiving fatal injuries
- One of the ship's cargo crane collapsed due to improper maintenance

The other accident took place onboard a container ship taking the life of a port worker. A corroded safety railing dislodged, and the port worker fell into the hold while leaning over the railing.

Finally, another explosion and a fire took place onboard a chemical tanker due to lube oil leaking into chemical cargoes because of lack of maintenances. This caused two injuries, one death and the subsequent abandonment of the vessel.

10.9 Suspected cargo shift/liquefaction

Three bulk carriers were lost due to suspected cargo shift or liquefaction making 36 persons missing.

Out of these three, one bulk carrier was lost during rough weather due to a suspected cargo liquefaction while carrying a cargo which was named as Group C cargo in the IMSBC Code.

The next bulk carrier was lost during rough weather because of cargo liquefaction due to noncompliance with the requirements provided in the IMSBC Code.

The final vessel was carrying cargo in bulk and was lost during rough weather due to a suspected cargo shift because of noncompliance with the IMSBC Code during loading. But, it was not very clear whether the fatigue played a contributory factor in this case when the master decided to enter a 'channel' where the vessel was capsized while experiencing gale force winds and a strong tidal stream coming in from the opposite direction.

10.10 Cargo lashing failures/improper lashing

Five accidents had taken place due to lashing failures/improper lashing. Out of these five, three were onboard container ships (without injuries), one onboard a Ro-Ro vessel (without injuries) and one onboard a general cargo vessel (causing one death and foundering of the vessel). All the accidents took place during rough weather.

Onboard one of the container vessels, the container stacks collapsed due to multiple reasons such as actual GM was higher than the maximum recommended GM, cargo weight distribution was not in accordance with the stack weight tables, containers were not lashed in accordance with the ship's Cargo Securing Manual, ship's stability computer was not fully utilized and high vibrations due to gale force winds etc.

On the 2nd container vessel, the container stacks collapsed mainly due to parametric rolling and other factors may include excessive stack loads, excessive racking loads, poor condition of the containers and structural failure of non-standard containers etc. This vessel was equipped with an 'onboard electronic motion monitoring, forecasting and decision support tool' which is a software which combines the ship's navigation and stability data with the weather forecast information and the ship's motion to aid the routing decision making process. But, the master and the bridge team were not very familiar with the use of the software.

On the last container vessel, the container stacks collapsed during rough weather since the actual forces on the container securing were higher than which was allowed by the vessel's cargo securing manual and the chief officer had not verified the compliance through the lashing software as he was not familiar with the lashing software.

Onboard the Ro-Ro vessel, cargoes were not lashed in accordance with the flag state requirements and the Cargo Securing Manual. At the same time, the company Safety Management System (SMS) onboard did not provide sufficient information with regards to lashing during heavy weather.

Finally, the general cargo vessel was lost taking the life of one person (bosun) due to multiple reasons such as timber deck cargo not being lashed in accordance with the cargo securing manual, insufficient stability, poor monitoring of weather, poor ship handling skills during rough weather etc.

10.11 Noncompliance with ship's stability

Two PCTCs happened to be abandoned without injuries during the passage as they were not having sufficient stability after the cargo operations.

One PCTC was abandoned while departing from the port with the pilot onboard. Apart from the shore cargo planner's inability to provide the correct cargo weights and the stowage positions onboard, the chief officer also had made errors in not assessing the departure condition of the vessel correctly. Which means that this accident was caused due to a chain of human errors which were caused by both the shore-based personnel and the ship's staff.

The other PCTC was abandoned during the sea passage as correct cargo and ballast water figures were not used in assessing the vessel's stability before departure.

10.12 Contact with liquid cargoes

Sulphuric acid was sprayed on a pumpman's face and body while he was trying to change a valve on the stripping line on an oil/chemical tanker while proceeding en route. Prior to opening the valve, he had opened the drain valve to make sure the stripping line was empty. He had removed the leaking valve safely and cargo was sprayed only when he was trying to tighten the new flange. This accident could have been avoided if the pumpman was wearing proper PPE.

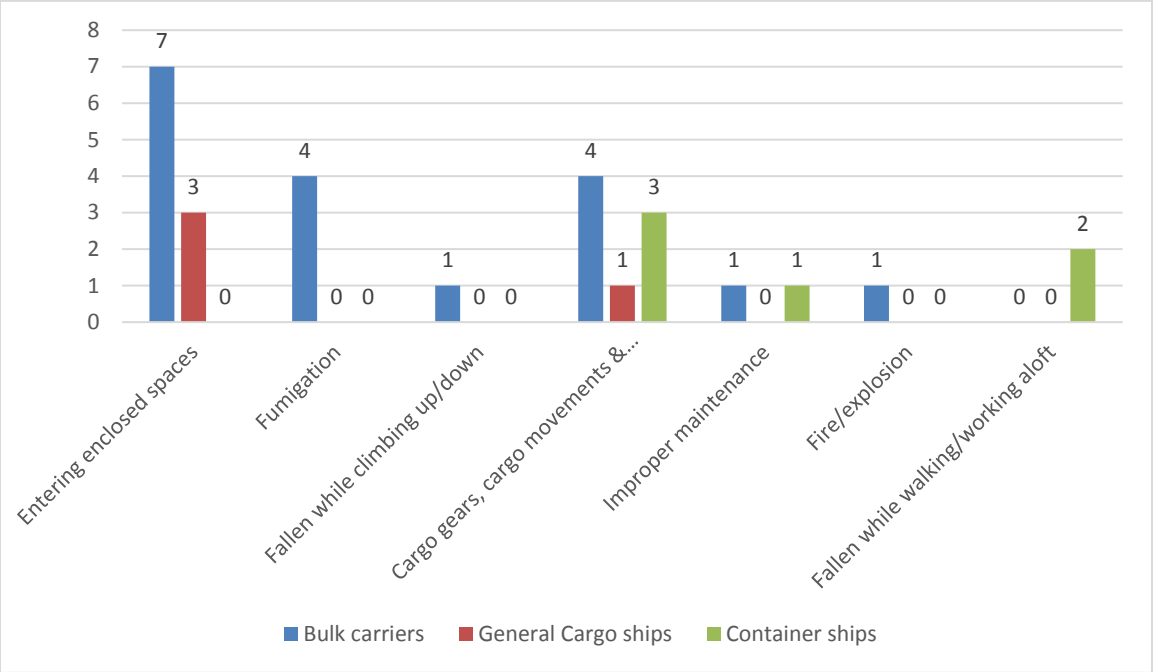
10.13 Cargo overflow

One oil overflow took place onboard an oil tanker causing no injuries. The oil overflow alarm was activated in the cargo control room before the overflow. But the 3rd officer who was monitoring the cargo operations acknowledged the alarm without paying much attention to it and without taking further actions.

11. Summary of deaths/injuries of port workers

11.1 Type of accidents and type of ships

Some of these accidents could have been avoided if the port workers cooperated with the ship's staff or if the ship staff managed to take reasonable precautions beforehand to eliminate the risks. 22 port workers had died and 6 were injured due to 18 accidents during cargo operations. The types of the accidents and the types of ships are as follows:



Deaths/injuries of port workers

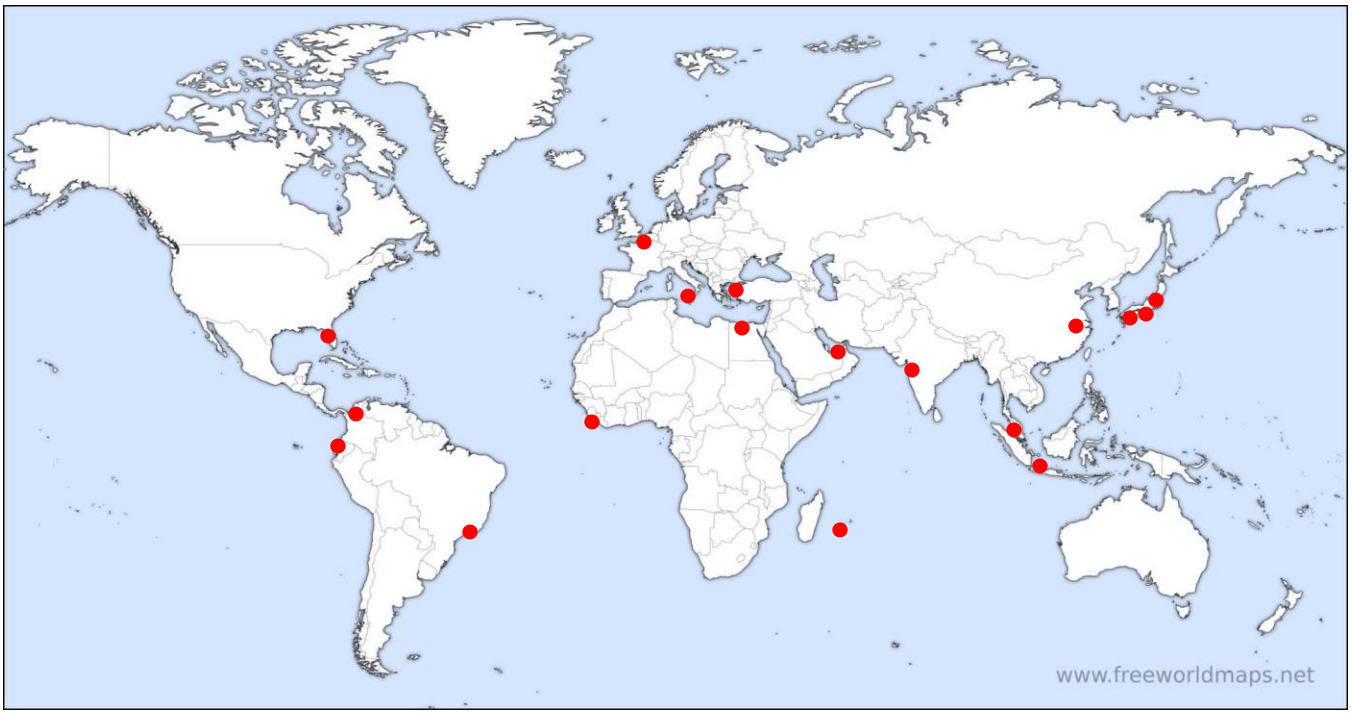
Graph – 11

In fact, when it comes to port workers, accident took place due to enclosed spaces and fumigation can be combined together. Most of the injuries and deaths had taken place due to entering enclosed spaces.

Most of the accidents to port workers had happened onboard bulk carries.

11.2 Geographical locations of the accidents

The said 18 accidents had taken place in the following regions of the world:



Geographical locations of the accidents [57]

Map – 1

As the accidents had taken place all over the world, no connection can be identified between the number of accidents and region of the world, but comparatively, the number of port worker accidents are lesser in the developed countries.

12. Contributory factors of the accidents

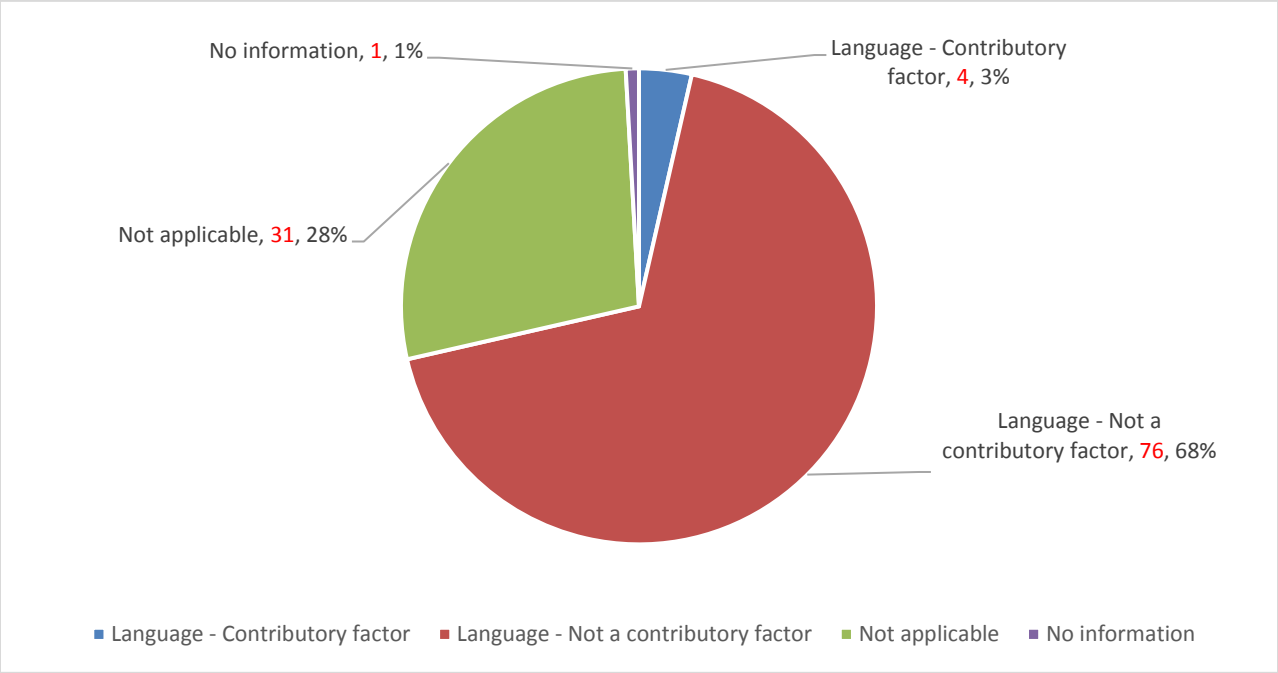
12.1 Language barrier during cargo related operations as a contributory factor

SOLAS states that, on all ships, to ensure effective crew performance in safety matters, a working language shall be established and recorded in the ship's log-book. The company, as defined in regulation IX/1, or the master, as appropriate, shall determine the appropriate working language [15]. IMO does not restrict the language used onboard ships but is required to have a working (common) language onboard.

If the working language used onboard is English, use of IMO Standard Marine Communication Phrases (SMCP) onboard will be very important to enhance the safety, security and pollution prevention. IMO compiled SMCP with the aim of

- assisting greater safety of navigation and of the conduct of the ship,
- standardizing the language used in communication for navigation at sea, in port-approaches, in waterways, harbours and onboard vessels with multilingual crews, and
- assisting maritime training institutions in meeting the objectives mentioned above [16].

It is not clear whether it is because of the use of SMCP or the use of native languages onboard, the language barrier was not a major problem in cargo related accidents onboard ships during the period considered.



Language barrier as a contributory factor

Graph – 12

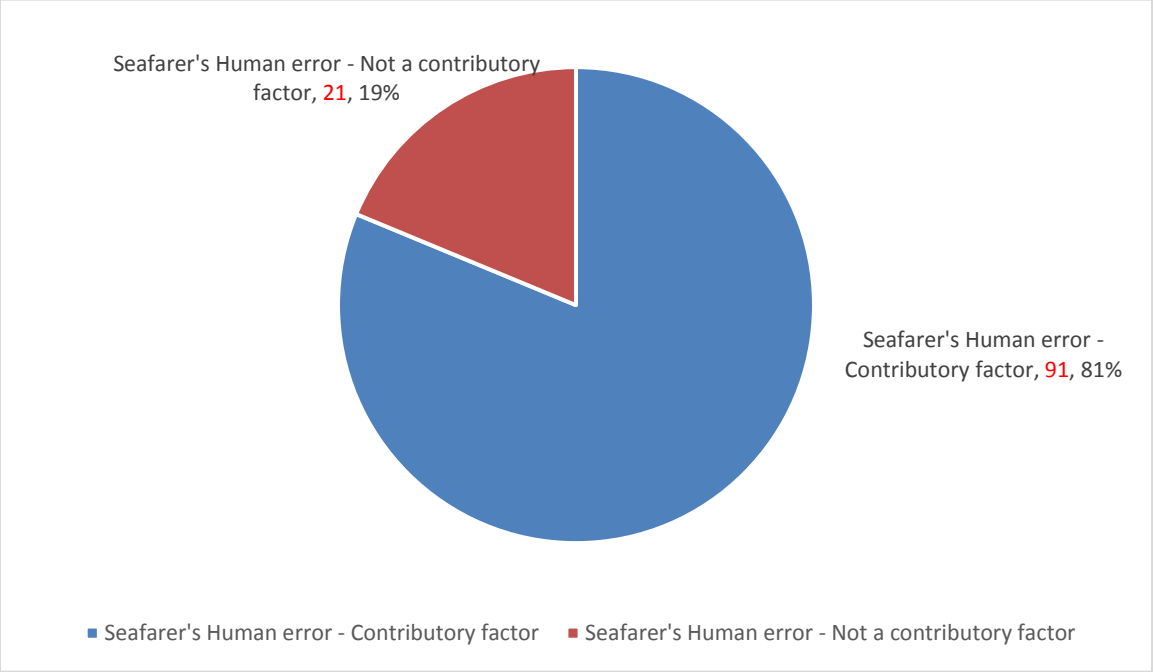
Miscommunication was not a contributory factor in 76 accidents out of the 112 total cargo related accidents. Language barrier was a contributory factor in four accidents only.

In the above graph, "Not applicable" means that there was no connection between the language barrier and the final accident incurred. Examples of "Not applicable" includes:

- accidents incurred while working alone after the instructions were understood
- accidents encountered while walking or climbing
- deaths of port workers caused due to falling down while climbing up/down ladders

12.2 Human error as a contributory factor

81% of the cargo operations or cargo related accidents had taken place due to the onboard staff's human error.



Human error as a contributory factor

Graph - 13

Even though the ISM Code became mandatory for all types of ships from 1st July 2002 to eliminate accidents due to human error, the implementation of it is questionable as most of the cargo related accidents had occurred due to human error of the seafarers.

Among the fulfilment of the intended purpose of ISM Code and maritime casualties, our findings indicated that the safety management system efficiency and the increased safety increase the probability of encountering an accident reduction at the highest level [17]. No doubt, an efficient

SMS and the increased safety will reduce the possibility of human errors. That was the reason to introduce SMS, a structured documented system through the ISM Code and Dimitrios [18] states that there is a reduction of accidents due to human errors onboard Greek flagged vessels engaged in coastal and inland water voyages after the implantation of the ISM Code. Similarly, Lappalainen, Kuronen & Tapaninen [19] states that the analysis of previous literature showed that the application of ISM Code in the shipping industry has significantly improved maritime safety in recent the years. So, there is a positive impact from the ISM Code on the reduction of the accidents due to human error.

But, still shadows of human errors exist and continue to play a major role in accidents onboard ships. Therefore, it can be stated that although the ISM-Code implementation led to a significant reduction of human-induced accidents, additional reduction is still necessary. Further studies in this field will lead to the adoption of additional regulations for the shipping safety [18].

12.3 Experience of the seafarers involved with the accident as a contributory factor

Experience of the persons injured and the persons in charge of the operation could be a key controlling factor in preventing accidents because the experience is the main driving force in improving competencies and professional judgements. Therefore, it is important to discuss the experience of the seafarers injured during the accidents and the person in charge of the operations. Therefore, the experience is categorized into three as below to gain an in depth understanding of the impact of the experience on the accidents:

- Experience with the company
- Experience in the rank and
- Experience with the type of the ship

In the Graphs 14, 15 and 16 below “Not applicable” with regards to “injured seafarers”, includes:

- Accidents involving port workers alone
- Seafarers onboard the three bulk carriers lost because of suspected cargo shift/liquefaction
- Accidents due to cargo lashing failures/improper lashing
- Noncompliance with ship stability
- Unknown nature of cargo and
- Similar situations where the injured person/s did not have any control over the accident

In the Graphs 14, 15 and 16 below “Not applicable” with regards to the person “in charge of the operation”, includes:

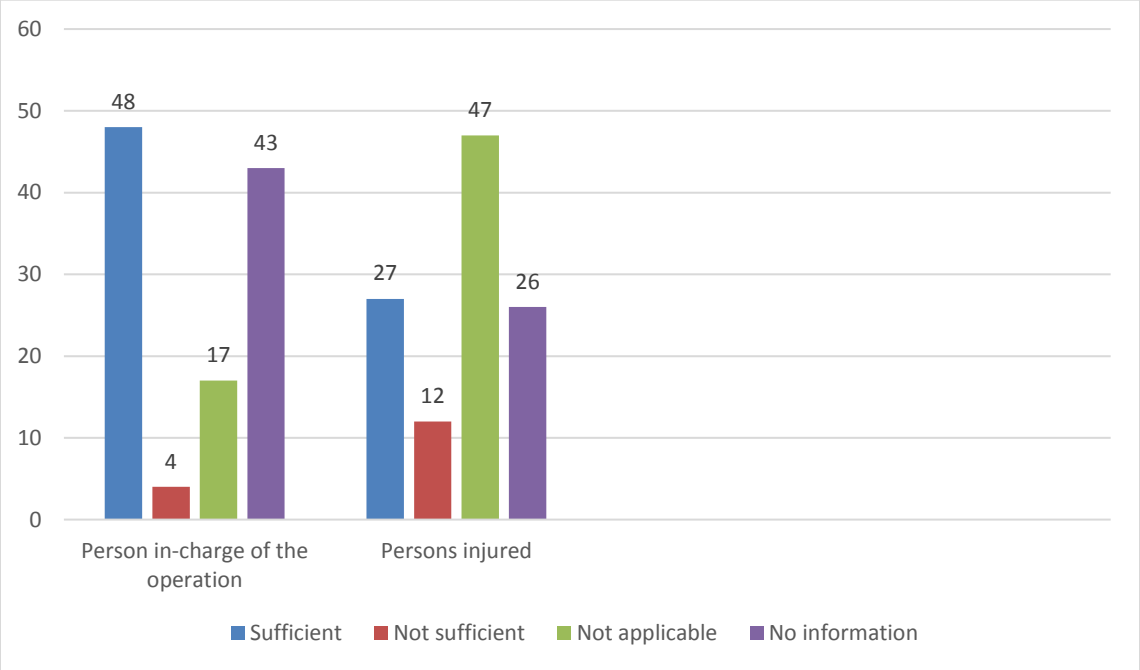
- Unknown nature of cargo
- Fallen while walking and

- Similar situations where the person in charge did not have any control over the accident

a) Experience with the company

Seafarers are required to have a good understanding about the company SMS as it regulates the working environment on board the vessel. Seafarers must adhere to the safe operational procedures described in the SMS during all operations and duties onboard.

Therefore, higher the experience with the company better the understanding about the SMS. Better the understanding of the SMS, the person in charge or the person injured could have prevented the accident. Therefore, it is worthwhile to look at the experience of the persons in charge and the persons injured with the company.



Experience with the company

Graph – 14

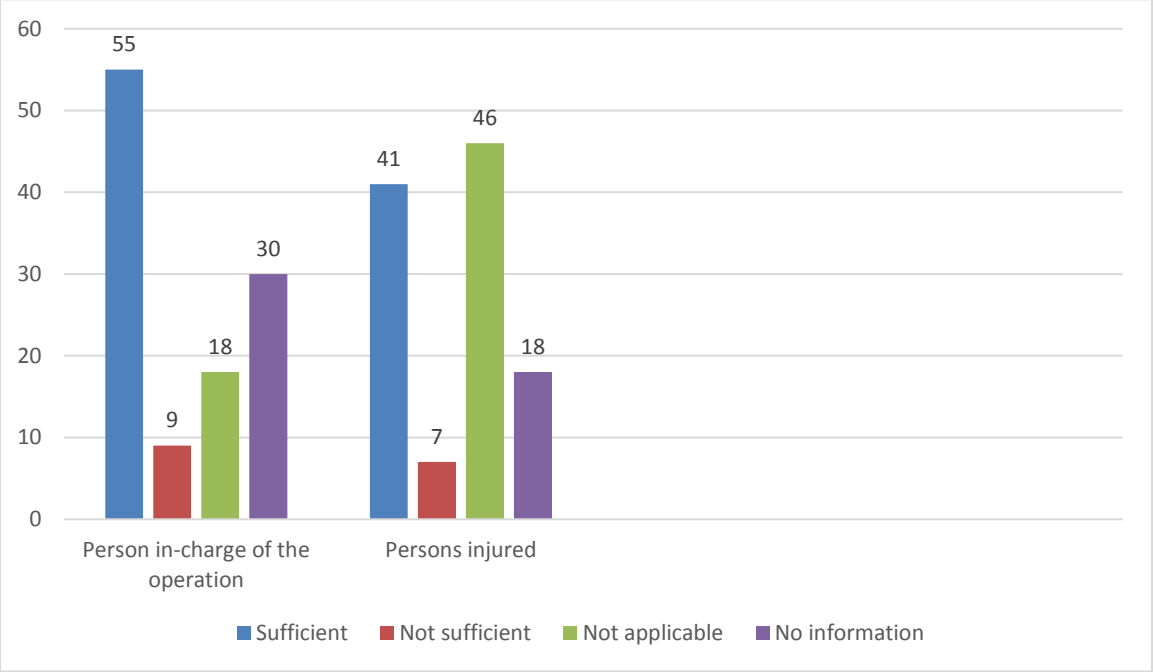
At first glance of the Graph – 14, it feels that the person in charge of the operation and the person injured both had sufficient experience with the company. But, sufficient information was not available in number of investigation reports to determine whether they had sufficient experience with the company or not.

In the worst-case scenario, if the number of "not sufficient" and the number of "No information" are added together, lack of experience with the company will become a critical factor for accidents during cargo related operations. Therefore, with this data, it is difficult to determine

whether there was a connection between the accident and the seafarer's experience with the company.

b) Experience in the rank

Seafaring career is mostly based on experiences. The classroom environment can not cover each and every problem that the seafarers may encounter during their life at sea. Even in considering eligibility criteria to do higher examinations (mates and masters) the candidates are required to have a certain amount of sea time, which in fact refers to the experience. Experience enhances the knowledge, competencies, skills and also the attitudes. Therefore, the experience in the rank could have an influence in minimizing the accidents onboard ships.



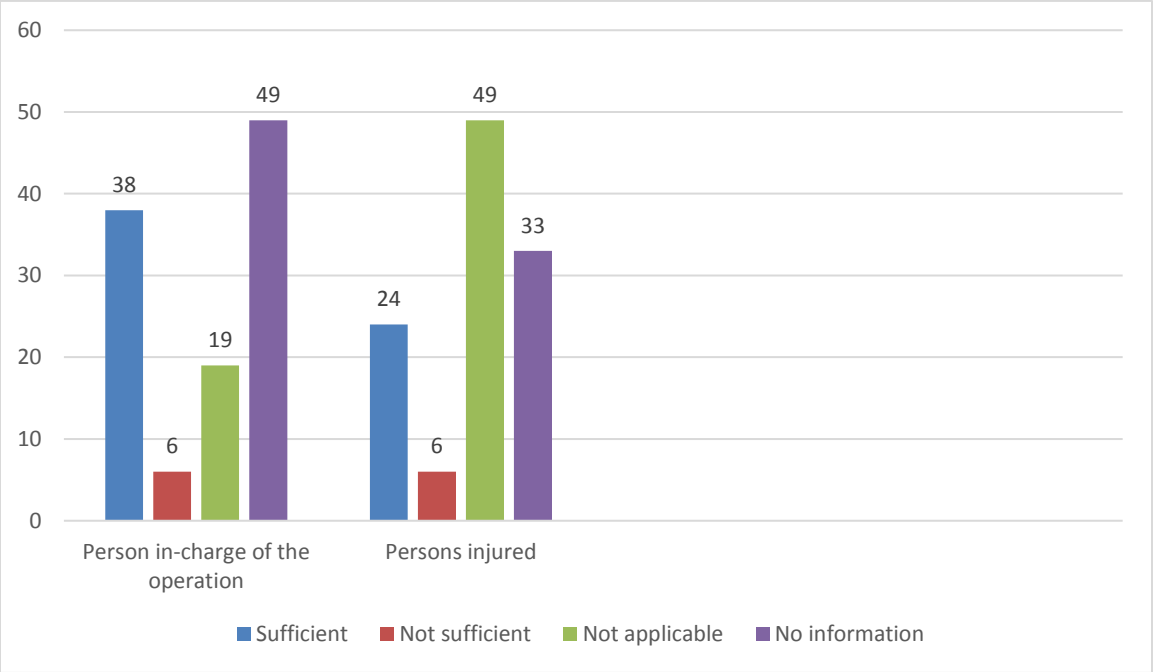
Experience of the seafarers with the rank

Graph – 15

It is quite amazing to note that in most of the occasions, the persons in charge and the persons injured both had sufficient experience with the rank.

c) Experience with the type of the ship

Experience with the type of the vessel also plays a very important role when it comes to cargo related operations rather than navigation. Therefore, it is important to evaluate the experiences of the persons in charge and the persons injured against the type of the vessel as well.



Experience with the type of the vessel

Graph – 16

In a number of accident investigation reports there had been insufficient information to determine the person in charge and the person injured had or had not sufficient experience with the type of the ship. Therefore, it is difficult to discuss about the connection between the accident and the seafarer's experience with the type of the ship.

With regard to all types of occupational accidents onboard ships, Erkan [6] states that there were no significant differences in the rates of injury severity by age, sea experience, and time on board when the accident took place. Of course, Erkan's statement is with regards to the occupational accidents which took place during all operations onboard. But, according to the Graph – 15 above most of the accidents relating to cargo matters had occurred with sufficient experience in the rank, but the impact on the accidents by the experience with the company and the experience with the type of the vessel is not very clear as there wasn't sufficient information in a considerable number of accident investigation reports.

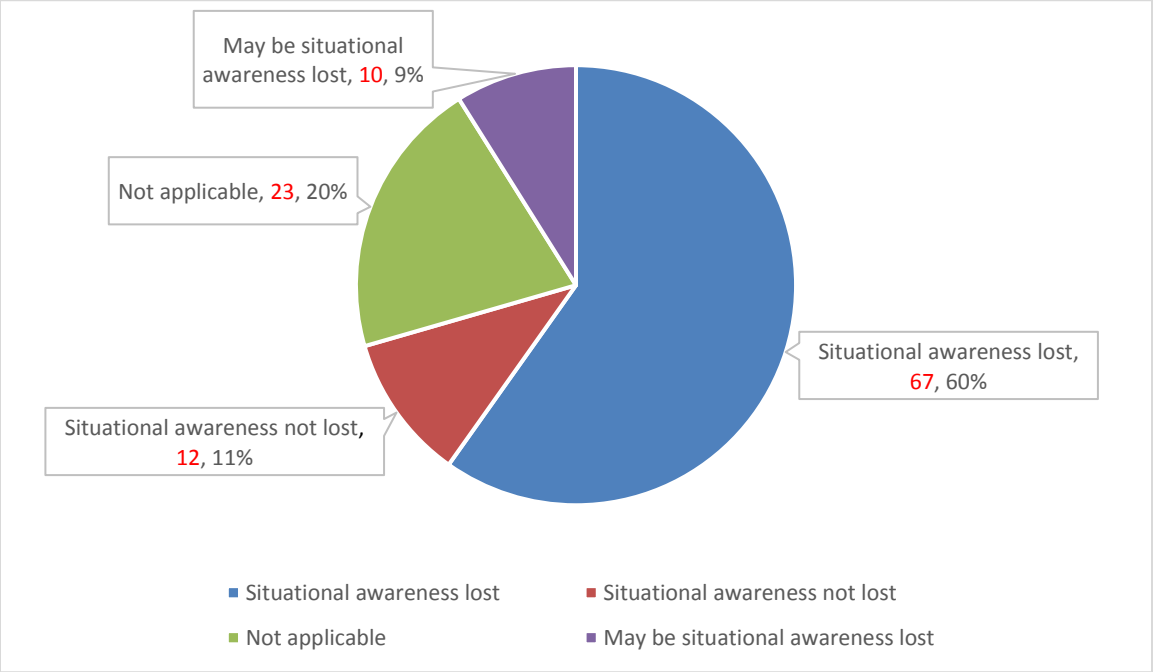
12.4 Lack of situational awareness as a contributory factor

Situational awareness – understanding what is really happening and assessing its impact on your voyage now and in the future [20]. Most of the maritime related articles highlight the important of situational awareness with regards to safe navigation. It is not wrong as most of the collisions occur due to human error which is partly or fully due to lack of situational awareness. In fact, maintaining a good situational awareness is important not only during navigation but during all operations onboard. When analysing accidents which occurred during cargo related operations, it was noted that lack of situational awareness was a contributory factor in most of the accidents.

In the following graph, not applicable (N/A) include:

- Accidents which occurred beyond the control of seafarers
- Few of the accidents incurred due to improper maintenance
- Few of the accidents which occurred due to unknown nature of the cargo

All of the accidents which occurred due to falling while climbing up/down ladders and while walking were considered as 'may be situational awareness lost' because, such an accident may occur due to medical problems as well and since the person who was injured is dead, cause of the fall is unknown.



Situational awareness

Graph – 17

60% of the accidents had occurred during cargo related operations partly or fully due to the lack of situational awareness. If the falls while climbing and walking also had occurred due to lack of situational awareness, then this will rise to 69%.

11% of the accidents had occurred without losing the situational awareness. Does this indicate that the persons in charge or persons injured were incompetent in those situations? As an example, a vessel loads a bulk cargo which was not correctly categorized in the IMSBC Code during rain for a couple of days. The master was worried about the rain and informs the company. The company informs to carry out a 'can test'. No evidence of carrying out a 'can test' to be found. The vessel sailed and was lost due to suspected cargo liquefaction during heavy weather. During loading everybody knew what was happening around them, but it was poorly analysed. This could happen due to incompetency as well. One could argue that this accident happened because the cargo was not correctly categorized in the IMSBC Code. But, carrying out a 'can test' when suspecting about the moisture content is a very common practice with the dry bulk trade. This is not to criticize the master or the company, but purely based on improving the future safety onboard. Therefore, accidents will occur while having situational awareness, but all the information was not put together and not correctly analysed. Which may happen due to lack of competency.

Out of the above 12 accidents that occurred with 'situational awareness not lost' the person in charge had;

- sufficient experience in the rank during 06 occasions (the experience with the rank was not sufficient in two occasions only)
- sufficient experience with the type of the vessel during 07 occasions (in the rest of the cases, there was insufficient information)
- sufficient experience with the company in 07 occasions (in the rest of the cases, there was insufficient information)

Does this mean that even the experienced people could be incompetent? Maritime Safety Queensland [21] states that situational awareness means having a good perception of your surroundings at all times, comprehending what's happening around you and predicting how this will affect your boat. Of course, this is regarding the safety of navigation, but the same can be applicable with regards to cargo related matters as well. In the case of the above 12 accidents, during most of the occasions, the person in charge had sufficient experience, they knew what is happening around, they had sufficient time to rectify the initial errors made and still they could not put everything together and predict the future consequences and finally ended up with an accident. This is most probably due to incompetency, especially with the type of cargo. Out of these 12 accidents, 06 had taken place onboard bulk carriers.

In the above Graph – 17, all the accidents incurred due to enclosed space entries are categorized as occurred due to lack of situational awareness. This type of accidents also may occur due to incompetency as well. But, having enough experience with other similar types of ships, having spent some time onboard, after doing enclosed space entries onboard and after participating with Enclosed space entry and rescue drills (Resolution MSC.350(92), IMO requires to have enclosed space entry and rescue drill to be conducted at least every two months and it became mandatory from 1st of January 2015) this type of accidents occurs most probably due to lack of situational awareness as this has become a routine work.

Then the problem remains why would another person go into an enclosed space without following emergency procedures after seeing the first person/s had collapsed. One may argue that it is the human nature. If it is the case, if human nature can overcome competency, it means incompetent in handling of emergencies. Therefore, incompetency had led the people to go to enclosed spaces without following emergency procedures to rescue casualties.

Situational awareness is addressed appropriately in Table A-II/1 and Table A-II/2 of the STCW Code, without addressing under 'Navigation' function alone as it is important for all operations onboard. This was added through the Manila amendments which was implemented on 1st January 2017. Therefore, most probably, none of the officers who were involved in accidents during this 5 year period were trained on situational awareness other than what they had gained through experience.

12.5 Risk assessment as a contributory factor

ISM Code requires the Companies to establish safeguards against all identified risks [22]. This was amended through Resolution MSC 273(85) which entered into force on 1st July 2010 requiring the companies to assess all identified risks to its ships, personnel and environment and establish appropriate safeguards.

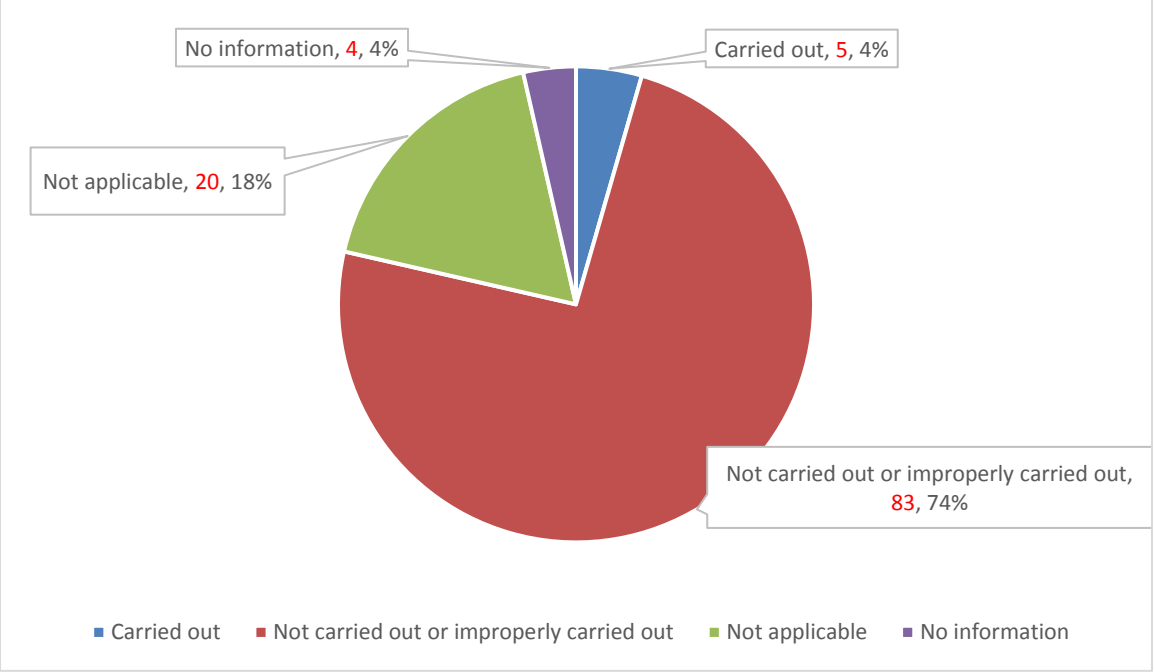
MLC 2006 states that each member shall adopt laws and regulations and other measures addressing the matters specified by the Code, taking into account the relevant international instruments and set standards for occupational safety and health protection and accident prevention on ships that fly its flag [23] which includes risk evaluation as well as training and instruction of seafarers [24].

MLC 2006 came into force on 20th August 2013 and it was applicable from that date to all the flag states that are considered in this research except for Hong Kong where it became applicable on 20th December 2018 [25]. Which means even though the risk assessment became compulsory for Hong Kong on 20th December 2018 through MLC 2006, it was compulsory for Hong Kong

flagged ships under the ISM Code well in advance and therefore, the risk assessment was compulsory for the flag states which are considered in this research during the 5 year period.

It is very sad to note that in 83 cases out of the 112 cargo related accidents, no risk assessments were carried out or the risks assessments were not properly carried out.

Proper risk assessments were carried out only in 5 accidents (4 % of total accidents).



Risk assessment conducted before the accident

Graph – 18

Even though the risk assessment became compulsory through the ISM Code and MLC 2006 some time ago, training of seafarers with regards to risk assessments became mandatory through the 2010 amendments to the STCW'78 which came into force on 1st January 2012 and implemented on 1st January 2017, which requires the officers in charge of watches and the chief officers to be trained on risk assessments.

STCW'78 as amended requires deck officers to be trained on risk assessment as below;

a) Table A-II/1 : Officers in charge of navigational watch on ships of 500 GT or more
b) Table A-II/2 : Masters & chief mates on ships of 500 GT or more
c) Table A-V/1-1-2 : Advanced training for oil tanker cargo operations
d) Table A-V/1-1-3 : Advanced training for chemical tanker cargo operations
e) Table A-V/1-2-2 : Advanced training for liquified gas tanker cargo operations

STCW'78 as amended states "until 1 January 2017, a Party may continue to issue, recognize and endorse certificates in accordance with the provisions of the Convention which applied immediately prior to 1 January 2012 in respect of those seafarers who commenced approved seagoing service, an approved education and training programme or an approved training course before 1 July 2013" [26]. Which means all the deck officers involved in the accidents have received training on risk assessments if the training programme had commenced after 1st July 2013. The date of commencement of the training programmes of the deck officers involved were not mentioned in the accident investigation reports.

For those who have completed the training programmes before 1st July 2013, the STCW'78 as amended states "Each Party shall compare the standards of competence which it required of candidates for certificates issued before 1st January 2017 with those specified for the appropriate certificate in part A of the STCW Code and shall determine the need for requiring the holders of such certificates to undergo appropriate refresher and updating training or assessment". But, no documents could be found with any member states requiring deck officers to undergo training related to risk assessment for those who have completed training programme before 1st July 2013.

Therefore, it is very doubtful that any deck officer involved with accidents had undergone training on risk assessments (unless company specific training was given) during the period considered. This problem may continue to exist if training on risk assessment is not provided for the existing deck officers.

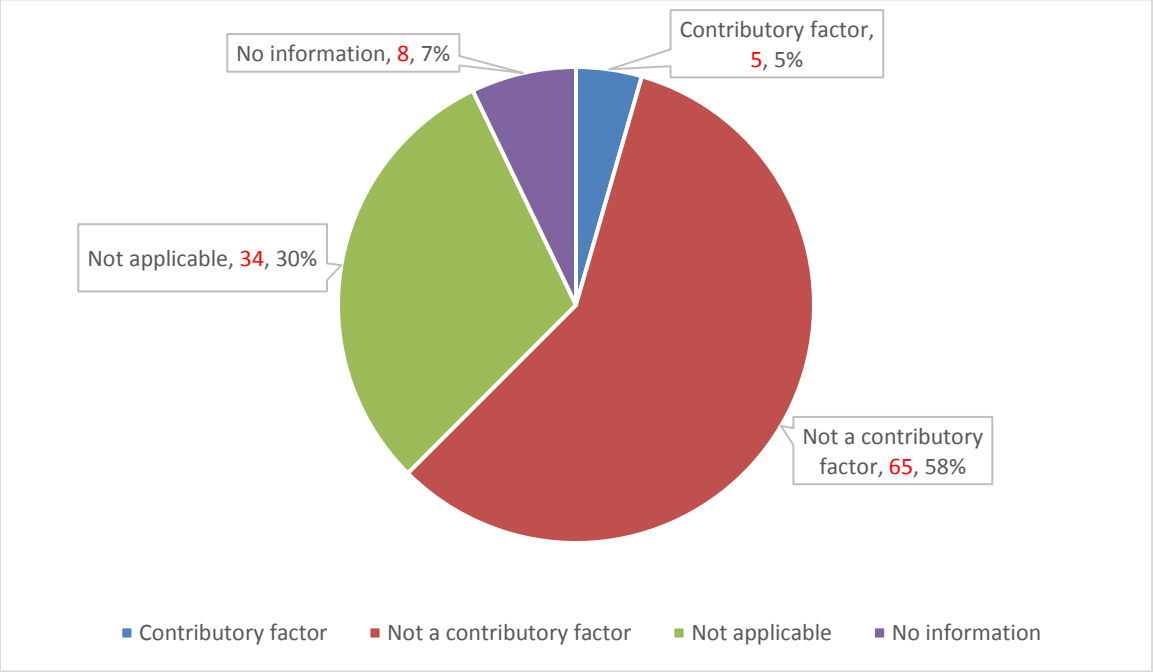
12.6 Fatigue as a contributory factor

Fatigue is a state of physical and/or mental impairment resulting from factors such as inadequate sleep, extended wakefulness, work/rest requirements out of sync with circadian rhythms and physical, mental or emotional exertion that can impair alertness and the ability to safely operate a ship or perform safety-related duties [27], which means without a doubt fatigue will lead to accidents onboard ships. Therefore, it is also better to see whether these accidents had occurred because of fatigue or not.

At the same time, accidents may occur, without any connection with the fatigue of the seafarers involved. These types of accidents are considered as "not applicable" in the Graph below and it includes accidents due to:

- ship losses because of suspected cargo shift/liquefaction
- unknown nature of cargo
- fumigation

- improper maintenance
- cargo lashing failures/improper lashing and
- any other situations where the accident couldn't be avoided even when the person concerned was not fatigued



Fatigue as a contributory factor

Graph – 19

In 65 accidents (58%) out of the total of 112 accidents, fatigue was not a contributory factor and only in 5 accidents (5%) fatigue may have contributed to the accident (suspected).

This could be due to the strict implementation of the work and rest hours mentioned in STCW'78 as amended and the MLC 2006 as amended, by the flag states, port states, shipowners and masters.

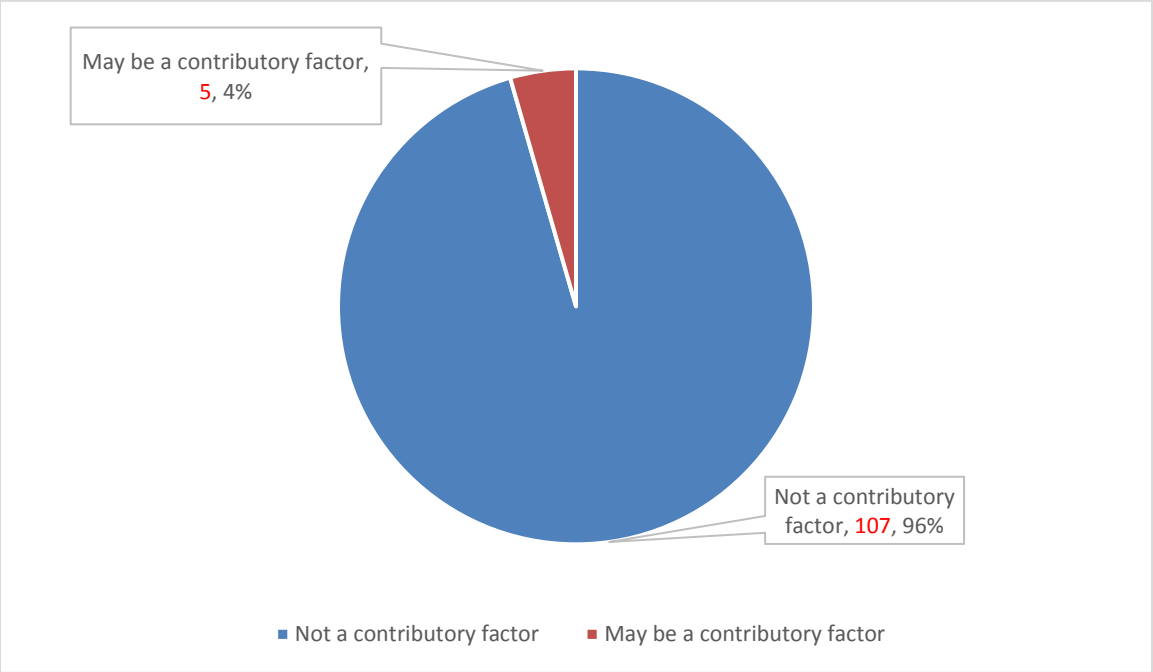
Whether fatigue was a contributory factor or not, is verified by referring to the recoded work and rest hours of the seafarers involved in the accident. But it is important to note that the quality of the rest or the sleep received cannot be monitored by referring to the records of work and rest hours.

12.7 Alcohol abuse as a contributory factor

STCW'78 as amended states that each Administration shall establish, for the purpose of preventing alcohol abuse, a limit of not greater than 0.05% blood alcohol level (BAC) or 0.25

mg/l alcohol in the breath or a quantity of alcohol leading to such alcohol concentration for masters, officers and other seafarers while performing designated safety, security and marine environmental duties [28]. This is simply because of the detrimental effects that the alcohol abuse can have on the safety of vessels.

Well, before the above requirements were implemented worldwide by IMO, some prudent ship owners had established stricter regulations than the above onboard their ships. Now, some of the ship owners have zero alcohol policies onboard their ships.



Alcohol abuse as a contributory factor

Graph – 20

May be because of the above strict requirements, even though seafarers have easy access to alcoholic beverages during cargo operations at ports, it is important to note that, out of these 112 accidents, alcohol abuse may have contributed only to five accidents.

Out of the above 5 accidents, one accident took place not because of alcohol abuse of seafarers but because of a drunken passenger on a Ro-Ro ship. Other four accidents involved intoxicated seafarers.

12.8 Noncompliance with the ship's SMS as a contributory factor

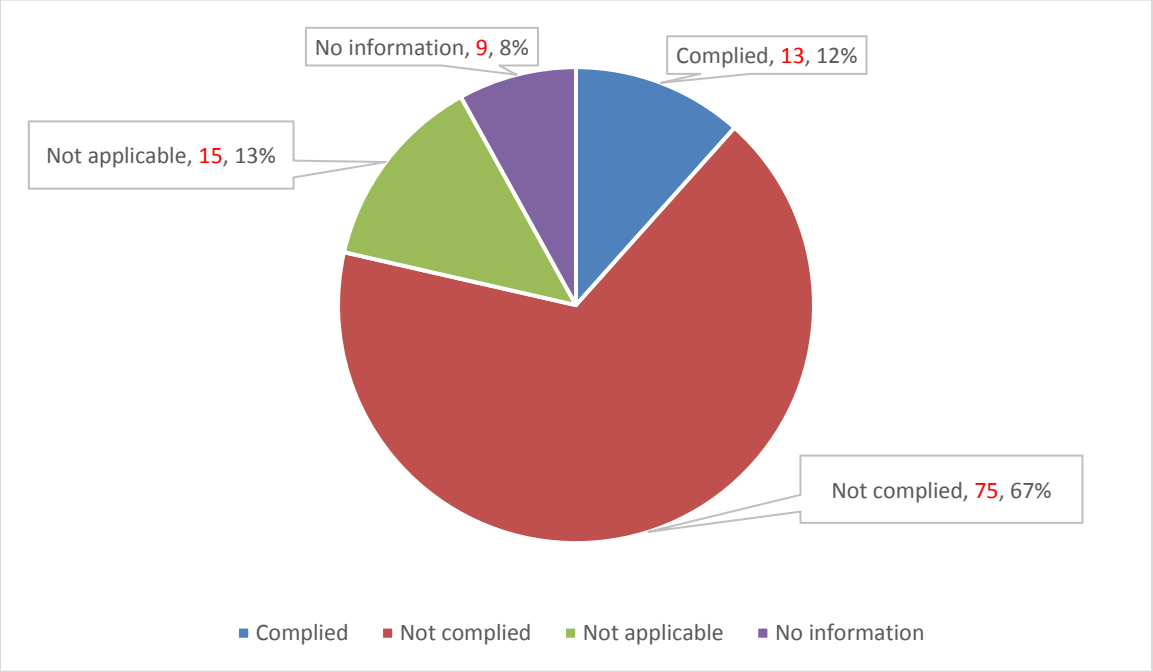
The ISM code became compulsory from 1st July 1998 for passenger ships, tankers, gas tankers, bulk carriers and cargo high speed craft of 500 GT and above. For other cargo ships and mobile offshore units of 500 GT and above, it became compulsory from 1st July 2002 [29].

The ISM Code requires every company to develop, implement and maintain a SMS with the aim of ensuring safety at sea, prevention of human injury or loss of life, and avoidance of damage to the environment, in particular to the marine environment, and to property [30].

SMS is a structured and documented system enabling Company personnel to implement effectively the Company safety and environmental protection policy [30].

Therefore, the company shall have to develop safety procedures for onboard operations and checklists to ensure the onboard operations are conducted as per the given procedures. It is highly essential to follow the given procedures as they will ensure the onboard operations are conducted safely.

It is amazing to note that in most of the accidents, the SMS had not been complied during this five-year period.



Compliance with the ship's SMS

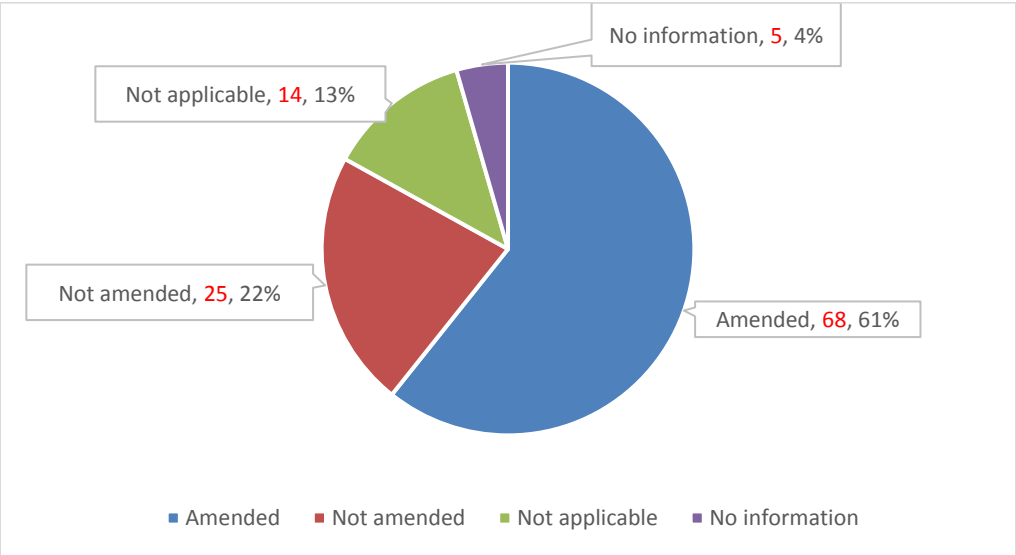
Graph – 21

This research is based on accidents 13 years after the implementing the ISM code on all ships of 500 GT and above. Yet, SMS was not complied with, in 75 accidents. In most of the accidents non-compliance with the SMS was a direct contributory factor for the accident to happen.

"Stop the Job" policy allows any member of the crew, regardless of rank, to demand that work on a particular job be stopped if they observe an unsafe action or perceive that something is unsafe [31], this is also called by some companies as "Stop the Work". This is not an IMO requirement but the companies themselves have introduced this through their SMS to enhance safety onboard. Out of these 112 accidents, there had been occasions where the companies have introduced this policy and the accident had happened because of the improper implementation of this policy onboard. Which again highlights the improper implementation of the SMS onboard ships.

13. Amendments to the existing SMS after the accident

As mentioned above, the SMS provides safe operational procedures. This structured documented system is a combination of requirements adopted by IMO, regulations implemented by the flag/coastal states, trade requirements, requirements of the ship's equipment manufacturers and the ship owners/managers requirements etc. In order to avoid accidents onboard, the SMS must reflect the exact safe working procedures onboard ships.



Amendments to the existing SMS after accidents

Graph – 22

The companies have taken steps to amend their existing SMS after 68 accidents as the investigations have revealed various deficiencies within the existing systems. Does this mean the SMS is not a proactive system, but a reactive system?

It is obvious that the safe operational procedures differ from ship to ship. Making a hundred percent perfect SMS on the first day of a ship is very difficult or may not be viable at all. That could be the reason why the ISM Code states that the master should periodically review the SMS and report it's deficiencies to the shore-based management. This should be done proactively in order to prevent predicted or possible accidents in the future.

In the case of these 112 accidents considered, only one vessel was having an interim Safety Management Certificate (SMC) as the vessel was only a few months old. All the other 111 vessels were relatively old and were having full term SMC.

Most importantly, in some cases it was noted that, even the very important elements of the safe working practices onboard were also not addressed in the ship's SMS.

14. Unsafe practices which did not contribute to the accident

Operations onboard ships may be completed without any accident:

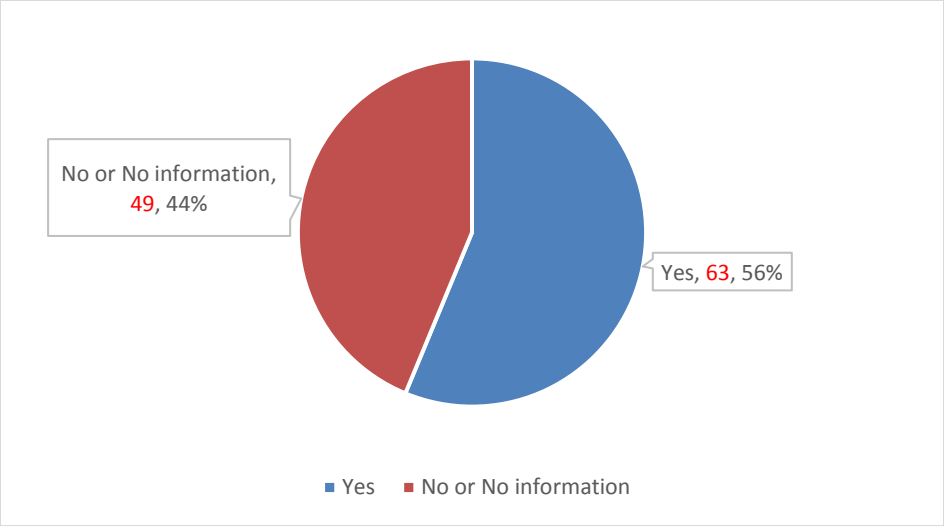
- by any means (example – without following correct procedures or without using correct Personal Protective Equipment (PPE), but luckily no accident had taken place).
- by following correct procedures, adhering to good seamanship practices and with professional judgements.

One may say that the operation is successfully completed if it is completed by either method mentioned above, which is wrong. An operation can be said ‘completed successfully’ only when it is completed in compliance with the second method above. Because, if the correct procedures are followed with good seamanship practices and professional judgment, operations can be completed without accidents whether the people who are engaged are lucky or not. If anyone tries to complete the operation by any means, there is a possibility that things may go wrong.

IMO introduced the system of near miss reporting to eliminate unsafe practices onboard. Near miss is defined as a sequence of events and/or conditions that could have resulted in a loss. This loss was prevented only by a fortuitous break in the chain of events and/or conditions. The potential loss could be human injury, environmental damage, or negative business impact [32].

Ship masters are required to report these near misses to the company. The objective of reporting near misses is that the company can decide whether further investigations or actions are required in order to avoid major accidents which may happen onboard in future.

As in the case of accident investigation reports, there is no requirement to make the near miss reports publicly available. Therefore, the interested third parties do not have access to these near miss reports to identify the actions to be taken to eliminate these unsafe practices. Because of this reason, these accident investigation reports were carefully examined to identify whether there were any unsafe practices onboard which did not contribute to an accident.



Unsafe practices onboard which did not contribute to the accident

Graph – 23

There were number of accident investigation reports which addressed the accident alone without much background information. In such cases, it was impossible to identify any unsafe practices which did not contribute to the accident. These figures were also added to the 'No unsafe practices' category because, even the 'No unsafe practice' category may not mean that there were no unsafe practices, probably, they were not described in the accident investigation report as they were not contributory factors. Yet it is surprising to see that there were unsafe practices in 56% of the accidents and that they did not contribute to the final accident.

15. Prevention of accidents during cargo related work

15.1 Implementation of the ISM Code onboard

a) Preparation of an effective SMS

As discussed earlier, in most of the occasions, the existing SMS was amended after an accident. This may happen if a proper SMS was not developed initially and if it is not reviewed effectively and proactively by masters.

The working arrangements differ from ship to ship. For example, if two bulk carriers are considered, unless they are cloned ships, carrying same type of cargo and running between the same ports, the safe working arrangements of the cargo related operations could be considerably different. Therefore, companies must make sure the safe working arrangements are properly and correctly documented, without which, one cannot be expected to follow the correct procedures.

In developing a new SMS there are couple of ways that can obtain the required information. Such as personal experiences, flag state requirements, guidelines/recommendations provided by various stakeholders in the industry, conventions and codes etc. As the existing conventions, codes and flag state law does not cover every bit and piece of all the types of duties onboard, most of the SMS will be based on the experience and the available information in the guidelines issued by other organizations as well. At present, the cargo related safety procedures are addressed in International Safety Guide for Oil Tankers and Terminals (ISGOTT), Code of safe working practices for merchant seaman (COSWP), Accident prevention onboard ship at sea and in port and Tanker Safety Guide (Chemicals) etc.

ISGOTT is published by the Oil Companies International Marine Forum (OCIMF) and is applicable for oil tankers. This publication is widely used onboard oil tankers and it is a comprehensive document which is also being updated frequently, covering most of the areas of oil cargo operations in general. Usually, the companies require their oil tanker vessels to carry this book onboard and comply with it. Shipowners use this as a guide in developing SMS with regards to cargo operations related duties as well.

Tanker Safety Guide (Chemicals) is published by the International Chamber of Shipping (ICS) with the aim of enhancing safety onboard chemical tankers. This is also a frequently updated comprehensive document which covers all the areas of chemical tanker cargo operations in general. Similar to the ISGOTT, this is also widely used by companies when developing procedures related to cargo operations and comply with the guidelines and recommendations provided in the book.

COSWP is a code published by the Maritime Coastguard Agency (MCA) UK. It is a very comprehensive and frequently updated Code which provides safe working practices covering wide areas such as mooring operations, maintenance work and cargo related operations etc. With regards to tanker cargo operations the COSWP refer to ISGOTT and Tanker Safety Guide (Chemicals) which could be considered a good practice. But COSWP is applicable only on British flagged vessels unless voluntarily used by ship owners or other flag states.

'Accident prevention onboard ship at sea and in port' is published by International Labour Organization (ILO). The objective of this code is to provide practical guidance on safety and health in shipboard work. This publication addresses cargo related safe working practices of all the types of cargo carrying ships. Even though it covers a wide area and cannot be considered as outdated, it does need updating. It is not in par with the present requirements which required by IMO. ILO very correctly states that a code such as this cannot cover every aspect of safety both at work and in off-duty periods aboard ship at sea and in port [33] still, reasonable steps should be taken to update the document covering the regulatory changes so that a fairly accurate SMS could be developed by the ship owning and management companies by referring to these kinds of publications.

On the other hand, the existing SMS was amended after the accident means, does it mean that the SMS must be an 'approved system' by the Administration or by a recognized organization or does it mean that the former masters have not reviewed the SMS effectively as required by the ISM Code?

Of course, having a hundred percent perfect SMS may not be practical from the 1st day of the delivery of the vessel. But this is the time for the IMO to consider whether to make the SMS an 'approved documented system' subjected to master's periodical reviews.

At the same time, The SMS shall be a "Living" or a "Breathing" system which includes, but not limited to effective communications (ashore, onboard and between the two), motivation, proactive thinking, evaluation, continuous reviewing and amending when necessary. Companies must encourage their masters to review the SMS effectively and proactively.

ISM Code requires that the company should carryout internal safety audits onboard at intervals not exceeding twelve months. The internal auditor will be checking whether the vessel is complying with the existing SMS during these safety audits. The internal auditor is an expert of the SMS and the master is an expert of the operations of the vessel. Therefore, this could be a perfect time to review the existing SMS as well, while checking the compliance rather than keeping that burden on the master alone.

b) Compliance with SMS

Reduction in occupational injuries could be achieved by improving the working environment and the quality of life on board, mitigating the mental and physical burden of work and developing policies to encourage the seafarers to obey safety rules and instructions [6]. ISM Code was implemented with the aim of improving the working environment onboard.

The ISM code has made shipping safer and cleaner over the past two decades [34]. Therefore, without a doubt, compliance with the SMS improves the safety onboard ships. It is the responsibility of the master inter alia implement the safety and environmental-protection policy of the Company and motivate the crew in the observation of that policy [30]. The master has a strong hold in implementing the SMS onboard a ship. He should be able to develop a safety culture onboard with the proper implementation of the ISM Code.

Safety culture defines the ways in which safety is managed on board a vessel and is reflected in the shared attitudes, beliefs, perceptions and values of the crew in relation to safety. Vessel owners, managers and masters have the pivotal role of embedding and driving a strong safety culture among their crews. If they do not portray a positive approach towards safety management, then it is likely their crew will adopt similar attitudes, and a poor safety culture will result [35].

The master is the owner's representative onboard a ship and therefore the master's attitude towards safety is very important in implementing the SMS onboard a vessel. A vessel represents both working and living environment where workers interact with each other more often than in other occupations. Therefore, it could be expected that master´s attitude towards safety and level of his involvement in safety activities will shape the safety behaviour of the crew members [36].

Even though there are various articles on importance of adopting a safety culture onboard, the STCW Code is silent on this matter. Therefore, Table A-II/2 of the STCW Code should be amended to include training on how to develop, implement and maintain a safety culture onboard and the industry should consider of providing similar training to existing chief officers and masters.

At the same time, the master himself cannot achieve this objective on his own. The company also has a serious role to play. If the masters, feel ignored and not listened to by the company´s management when they demonstrate concern regarding safety issues gradually, they can develop a negative attitude and in the maritime transport seafarers are faced with notable hazards. Therefore, it is important to address various issues within maritime safety, one of them being safety culture [36].

Therefore, companies shall also ensure the ISM Code is properly and effectively implemented and a safety culture is maintained onboard to achieve the best results of the ISM Code. Just having a SMS without proper implementation onboard will not enhance the safety.

On the other hand, if there are any changes to the existing SMS, companies must have a system to upgrade their masters, officers and engineers who are on leave so that they are well aware of the changes before their next contract onboard. This can be done without an expense to the company with the aid of e-mails.

There were considerable unsafe practices which did not contribute to the accident as well and at the same time during this research it was noted that lot of other accidents such as collisions, grounding, accidents during maintenance also had occurred due to improper implementation of the SMS onboard. Specially, several years after the implementation of the ISM Code. Therefore, noncompliance with the SMS is a serious threat to the safety onboard. Flag states and shipowners should take immediate and proactive measures to ensure the SMS is strictly implemented onboard.

Port states, flag states, ship owning companies should consider of having awareness programmes to seafarers to make them understand the importance of complying with the SMS, most suitably with the aid of case studies.

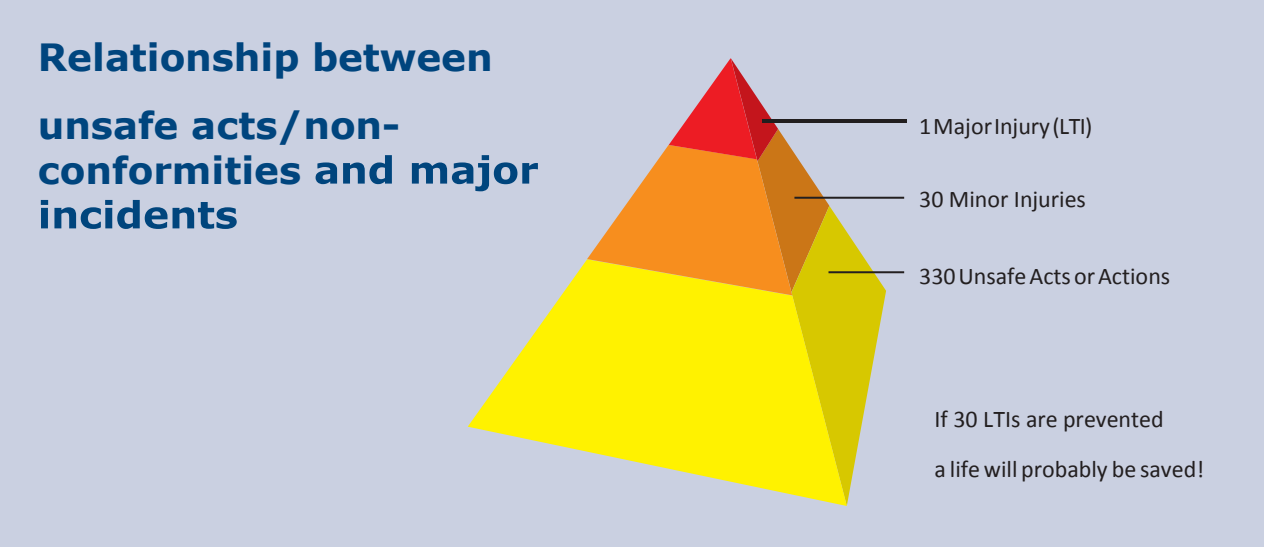
c) Sharing of best practices within the industry

Einarsrud [37] says that several shipping companies had quality systems established and certified ahead of the entry into force of the ISM Code and he further says that these companies had realised that the competitive advantage and other benefits that could be gained by implementing a documented quality system. Which means, the standard shipping companies take proactive measures to improve safety, security and pollution prevention. The ‘stop the job’ policy is also a similar approach adopted by some companies, even though it is not compulsory by any convention or code.

Similar to the ‘stop the job’ policy there could be other various initiatives taken by the safety conscious companies in order to reduce accidents onboard their ships. These types of best practices in the industry could be incorporated to the existing guidelines and codes, making those best practices compulsory, or known worldwide.

d) Near miss reporting

Various scholars have also shown that for approximately every 330 unsafe acts or non-conformities, 30 are likely to result in a minor injury. Of these 30 injuries one is statistically likely to be a Lost Time Injury (LTI). Thus, the prevention of 330 unsafe acts is likely to prevent a significant injury. Statistics also suggest that the prevention of 30 LTIs is likely to result with the saving of a life! This concept is illustrated by the safety pyramid diagram below [38].



LTI – Lost Time Injury also known as Lost Time Accident (LTA) [38]

Diagram – 1

The above numbers (i.e. 1 major injury per 30 minor injuries and 30 minor injuries per 330 unsafe acts) are not important and it is doubtful to say that major injuries always happen after so many number of minor injuries. But what is important here is, after analysing the unsafe acts depending on the seriousness or the likelihood of occurrence, may take actions to eliminate future suspected minor injuries, major injuries and most importantly, it would be essential in developing a safety culture onboard a ship. That is why reporting of near misses are important.

A near-miss means a sequence of events and/or conditions that could have resulted in loss. This loss was prevented only by a fortuitous break in the chain of events and/or conditions. The potential loss could be human injury, environmental damage, or negative business impact (e.g., repair or replacement costs, scheduling delays, contract violations, loss of reputation) [32].

On the same Circular, there are some examples for the near misses as below:

- Any event that leads to the implementation of an emergency procedure, plan or response and thus prevents a loss. For example, a collision is narrowly avoided; or a crew member double checks a valve and discovers a wrong pressure reading on the supply side.

- Any event where an unexpected condition could lead to an adverse consequence, but which does not occur. For example, a person moves from a location immediately before a crane unexpectedly drops a load of cargo there; or a ship finds itself off-course in normally shallow waters but does not ground because of an unusual high-spring tide.
- Any dangerous or hazardous situation or condition that is not discovered until after the danger has passed. For example, a vessel safely departs a port of call and discovers several hours into the voyage that the ship's radio was not tuned to the Harbour Master's radio frequency; or it is discovered that ECDIS display's scale does not match the scale, projection, or orientation of the chart and radar images.

All these examples refer to an unsafe practice and accidental avoidance of an accident. What if a person working on deck without helmet does not experience anything passing over his head? In accordance with the above definition and the examples, it is not a near miss. Therefore, it does not require reporting. This incident may be considered as an unsafe practice. If this unsafe practice is continued, there could be an accident in future. Therefore, IMO should consider of making it compulsory to report unsafe practices as well as near misses.

Some masters complain that their companies require so many numbers of near misses per month. Which means, sometimes the masters are forced to write some near misses without actually happening them. No company can improve safety onboard ships by collecting near misses which have not occurred at all or by increasing the number of near miss reports.

On the other hand, there is no point in just collecting the near miss reports. Somebody ashore must analyse them and evaluate the risk by taking the following into consideration:

- Frequency of similar near misses
- Severity if it continues
- Types of ships
- Trading routes
- Manning levels onboard
- Ranks involved
- Nationalities onboard etc.

Then only the company will be able to understand the areas which need immediate attention to eliminate the risks, which may include but not limited to;

- special training to be provided to the crew onboard,
- whether increased manning levels onboard is needed (higher than required by the minimum safe manning document),
- whether additional equipment onboard is required
- whether SMS needs amending etc.

Then that information needs to be passed to the floating staff requesting the master's opinions. Therefore, rather than collecting and counting the number of near misses, near-miss cases and unsafe practices must be studied, evaluated and analysed to identify the future risks. This will lead the company towards a proactive decision-making process to enhance safety. Then only the reporting of near misses will become a part of 'living' or 'breathing' SMS. Analysis of near misses received shall be strictly audited during the ISM audit of the company.

e) The missing link

Even though this is beyond the scope of this research, it is better to address the safety of the port workers coming onboard, as most of these accidents can be eliminated by proactive actions of the deck officers and deck ratings onboard.

The master and the company have the full control over the vessel in implementing the ISM Code onboard. But, when it comes to port and ship's interface, there is a problem. The author with his own experience has noticed port workers:

- do not use proper means of access to the ship (using ship's cargo gears to go from ship to berth and vice versa, jumping over the railings when deck and the jetty both are at the same level etc.)
- trying to open, closed unnecessary compartments onboard
- sleeping or resting in inappropriate or dangerous places onboard etc.

After taking various actions to avoid the above unsafe acts, such as advising them several times through their foreman or directly to them, warning them, switching off the power to cargo gears etc. still whenever the duty officer or the duty AB (deck) is away from the scene, again they tend to commit the same faults. Some years ago, this was an ongoing problem in some parts of the world specially in container, bulk cargo and general cargo berths/ports. They also refuse to sign safety related documents/checklists as evidence that the chief officer has explained the safety related issues onboard and they have understood the same.

In accordance with the accident investigation reports, these unsafe practices are still happening. One of the accident investigation reports state that despite the Chief Officer having discussed all the items of the form T-04 with the stevedore foreman, he refused to sign and confirm the 'form T-04' [39]. This gap between shore and ship may jeopardise the safety of both, shore, and ship.

There are no international training and certification requirements with regards to port workers who work onboard ships. Most of them may have learnt onboard operations from their colleagues while performing the functions of a cargo handler or signalman or tallyman etc. There could be various problems in standardizing of training and certification of the port workers

globally. Therefore, at least the port states and the port authorities should take actions on their own to implement good practices for the safety of their own countrymen.

The port states and the port authorities may also will be reluctant to implement good practices as they do not know what is happening in other ports around the world as there is a lack of information flow. Therefore, there must be a means of circulating or sharing this sort of information (accident investigation reports related to port workers) among the port states and the port authorities, so that they can carry out risk assessments and proactively evaluate the training needs of their own port workers.

Port workers should be educated to understand the basic safety onboard ships, safety related communications with the ship's personnel, signing of checklists and compliance with the contents of the checklist. After the foreman sign the safety check list, he should have a meeting (similar to a toolbox meeting onboard) with the port workers, to make them understand the contents of the checklist before the commencement of work onboard.

The bulk and general cargo ports and berths shall take actions to educate their port workers with regard to dangers, identification and emergency procedures of enclosed spaces.

There are various safety signs used onboard ships as they are required by the SOLAS and the ISPS Code. But there are no internationally accepted signs to mark enclosed spaces indicating the danger inside the space. Therefore, need to consider of using an internationally accepted prohibition sign, highlighting the danger if entered, to mark enclosed spaces and the port authorities must take actions to educate their port workers in identifying the enclosed spaces.

15.2 Training & education as per the STCW Code and other areas to consider

Following suggested amendments for the STCW Code are based on the outcomes of this research and gaps identified between current practices on board and the relevant Tables of the STCW Code with regard to safe cargo related operations onboard.

a) Risk assessment

As mentioned before, training on risk assessment became mandatory through the Manila amendments and therefore, those who were trained and certified prior to the Manila amendments may not have received training on risk assessments unless required by the company. Therefore, companies should consider providing at least onboard training on risk assessment to existing officers and ratings who have not received such training.

At the same time, in accordance with the STCW Code, no training in risk assessment is required for deck ratings. Specially, for the bosuns and deck ABs even though they are engaged in various cargo related operations throughout the day. The bosun is the head of the deck ratings and the ABs are responsible persons who are allowed to carry out duties alone. If the initial working environment is changed or if the situation is changed, need to re-assess the risk. Therefore, bosuns and the AB should be given a basic training on risk assessment (at the 'support level') so that they may contact the responsible deck officer in case of change of circumstances or when they are in doubt, to get the risks re-assessed.

It is also better to provide similar approved training at least at the 'support level', for pumpmen on tankers as they are also allowed to work alone.

b) Obtaining and maintaining situational awareness

For the best situational awareness, it is important to use all your senses: sight, hearing, smell, touch – even taste [40]. While collecting all the information by using all the senses, one needs to concentrate on their own work to make sure the job is being done without errors. As an example, a person climbing up a ladder must concentrate on climbing up. He must make sure to use 'three-point contact'. While we are walking, we use 'one-point contact'. We do not need to think about it, because we are born with that ability. But we are not born to use 'three-point contact', therefore, always required to keep in mind to use 'three-point contact' while climbing ladders. At the same time, it is important to remember to place the middle of the foot on the rungs of the ladder while climbing. If the concentration is lost, these things may not happen. Therefore, situational awareness includes concentration on the own work as well.

At the same time, the situation may change during cargo related operations onboard ships from time to time. When the situation is changed, it is required to carry out a risk assessment again to identify whether there are new risks involved. To carry out a risk assessment, a person who is qualified and authorized should be informed, preferably a deck officer. To inform a deck officer, those who are engaged in the work should know that the situation has changed.

Therefore, not only the leader of a team, but the entire team must have a good situational awareness throughout the operation. Table A-VI/1-4 of the STCW Code shall be amended to include obtaining and maintaining situational awareness.

As mentioned before, the existing deck officers may not have received training on obtaining and maintaining situational awareness. Therefore, it is better to provide a training to the existing staff onboard on situational awareness at least through the senior officers.

Ever since mobile phones came into existence, it has become a normal practice to use mobile phones whenever the signals are available, especially when the vessel come to a port as the seafarers can buy phone cards at a cheaper rate. Hindering seafarer's freedom to call their loved ones is not ethical at all, but it must not interfere with the cargo operations and other work onboard in order to maintain the safety. It is obvious that the use of mobile phones may distract the situational awareness. Even though there are regulations implemented through SMS prohibiting the use of mobile phones during duty hours onboard, there are no restrictions implemented internationally. Therefore, internationally prohibiting the use of mobile phones during working hours for personal matters should be considered.

c) Prevention of accidents by cargo gears, cargo movements & moving objects

Table A-II/1 of the STCW Code is completely silent on cargo lifting appliances. It is obvious that the knowledge of 'safe operation of lifting appliances' at the operational level can be obtained during the compulsory onboard training period. But, if the trainee happens to sail on gearless vessels during the training period, he/she will be certified without much knowledge on cargo lifting appliances. Therefore, knowledge of the 'safe operations of cargo lifting appliances' at the operational level should be added to the Table A-II/1 of the STCW Code.

Table A-II/2 of the Code addresses '*cargo-handling gear*' and there were no differences between the Manila amendments and post Manila amendments. Therefore, it can be assumed that the chief officers have sufficient knowledge with regard to cargo handling gears.

In accordance with the Table A-II/5 of the STCW Code, AB (deck) are required to have KUP on the '*use on handling of deck and cargo-handling gear and equipment which include cranes, derricks and winches*'. Even though some AB (deck) may not have received the required training as explained earlier, the content of the Table II/5 of the STCW Code with regard to cargo gears can be considered sufficient.

IMO states that the draft SOLAS regulation II-1/3-13 covers requirements for the application, design, construction, operation, inspection, testing and maintenance of onboard lifting appliances and anchor handling winches [41]. After adopting the regulation, it should be quoted in the Table A-II/1 and Table A-II/2 of the STCW Code.

Maritime Coastguard Agency (MCA), UK has issued guidance with regard to freight vehicle operations on Ro-Ro ships in two publications, namely the COSWP and 'Roll-on/Roll-off Ships – Stowage and Securing of Vehicles'. These two publications provide comprehensive information with regard to freight vehicle operations. ILO also addresses the freight vehicle

operations in Accident prevention onboard ships at sea and in port. Same as the two MCA Codes, the ILO Code of practice is also silent on the eye contact between the signalman and the driver. This signalling is little different from signalling to a person operating a crane onboard. In case of a crane, usually the signalman is well away from the cargo. In case of marshalling vehicles, the signalman is very close to the cargo. The signalmen must be instructed not to lose their eye contact with the driver (directly or through mirrors) until the vehicle is parked, brakes applied and engine stopped. Therefore, it is better to include such instructions on MCA and ILO Codes.

All the other accidents which occurred due to cargo gears, cargo movements & moving objects could have been avoided if the person injured had a good situational awareness and had completed a risk assessment.

d) Prevention of accidents by entering enclosed spaces

As discussed earlier, officers and ratings (except for AB) on ships of other than tankers had received training on enclosed spaces during the PSSR programme only.

ABs (deck) on ships of other than tankers are receiving training on enclosed spaces during both the PSSR and AB (deck) programme. But the AB (deck) programme is not compulsory as explained earlier.

This means, on other ships apart from tankers, seafarers had received training on entering enclosed spaces at least once before joining the vessel.

Similarly, officers and ratings working onboard tankers had received training on enclosed spaces at least during two programmes. This is self-explanatory when referring to the respective tables of the STCW Code.

Subsequently, 'revised recommendations for entering enclosed spaces aboard ships' [13] were adopted on 30th November 2011 by IMO requiring carrying out enclosed space entry drills periodically, without stating a specific time period. But, conducting drills for enclosed space entry every two months became compulsory onboard ships from 1st January 2015 through the amendments to SOLAS (Resolution MSC.350(92), IMO).

Table A-II/1 and Table A-II/2 of the STCW'78 as amended is silent with regard to entering enclosed spaces. But, the Chief mate candidates are required to have KUP with regard to the a*bility to establish procedures for safe cargo handling in accordance with the provisions of the relevant instruments such as IMDG Code, IMSBC Code* etc. The IMSBC Code again refers to

the above ‘revised recommendations for entering enclosed spaces aboard ships’ with regards to entering enclosed spaces. Which means the same topic is discussed again while undertaking the chief mate programme as well.

Therefore, the present education and training for seafarers with regard to enclosed space entries can be considered sufficient. However, due to the higher risk in entering enclosed spaces, it may be highlighted again in Table A-II/2 of the STCW code as discussed below under the heading of ‘Prevention of accidents by fumigation’.

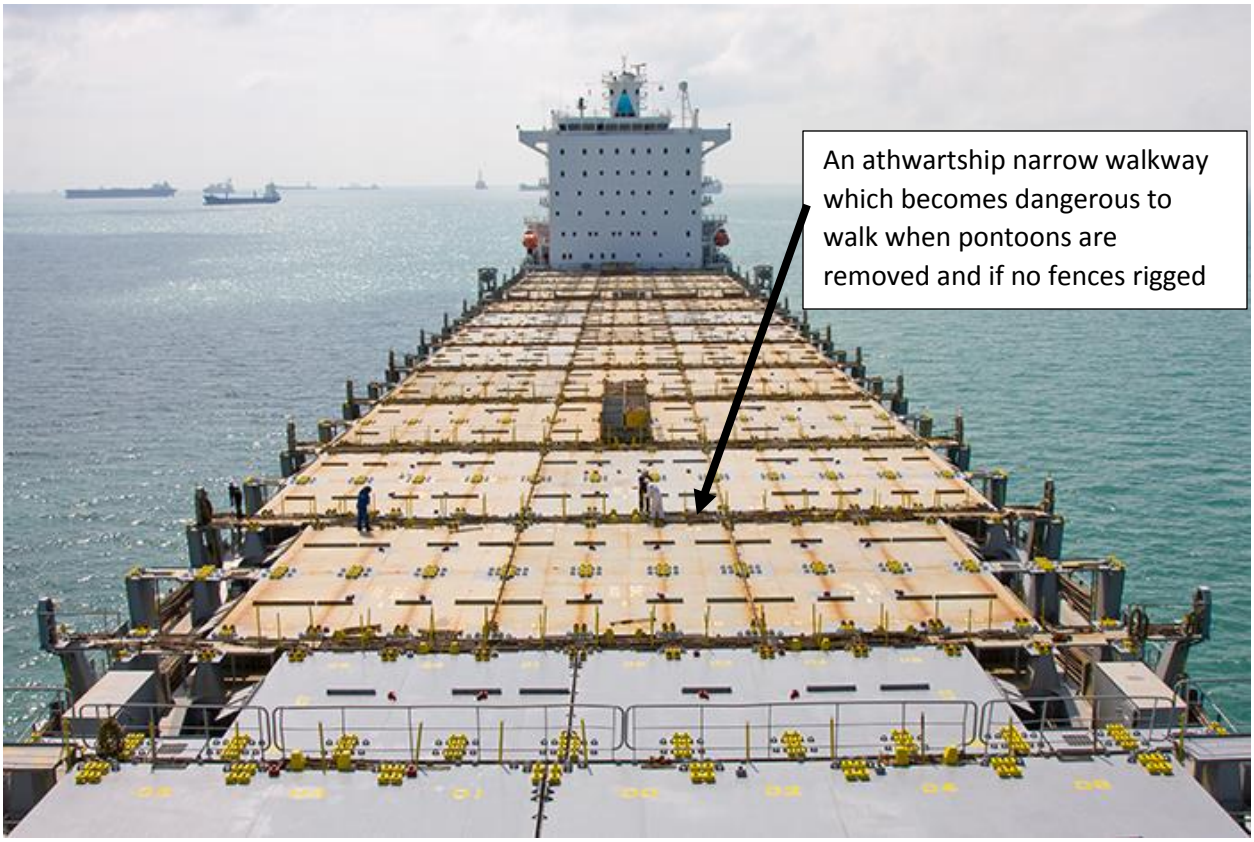
Accidents caused due to entering enclosed spaces can be eliminated by 100%, unlike other types of accidents. Because seafarers enter enclosed spaces purposely (knowing that they are entering an enclosed space). Entering an enclosed space is not a coincident. The problem is simply not following the safe procedures.

The next available option to eliminate this type of an accident is to organize a worldwide awareness programme to gain the attention of the seafarers and ship owners by IMO, flag states and port states. This could be done without much cost by using emails, social media etc. Probably, IMO can consider having a motto for few months of this year as ‘zero accidents in enclosed spaces’.

As discussed above emergency handling of enclosed space entries were very poor. This should also bring to the attention of the seafarers, and it is necessary to consider making it mandatory to have a drill for enclosed space (may be a refresher drill) for new joiners within a week after joining a vessel, especially on tankers and bulk carriers.

e) Prevention of accidents by falling while walking/working aloft

No training programme can be developed through the Tables of the STCW Code on ‘How to walk onboard’ but, occupational accidents while walking can be reduced by carrying out a risk assessment, adhering to applicable PPE and having a good situational awareness. This problem mainly exist on container ships as there are athwartship narrow unprotected (without fencing) gaps between cargo holds. These gaps may become very dangerous to walk between when hatch covers on either one end or both have been removed and when the container securing materials are scattered around. On top of that, there may be no illumination in these areas (above the hatch coaming) during dark hours unless from the shore or through the shore-gantry lights.



Athwartship narrow pathways on board a container ship [42]

Figure - 1

Need to prohibit the use of unprotected walkways unless sufficient width for safety is available and fences are rigged or else need to comply with safe working aloft procedures.

Most of the accidents under this category had occurred not while walking but while working aloft during cargo related matters. Therefore, it is necessary to concentrate more on occupational accidents due to falling while working aloft.

There is nothing mentioned about working aloft in the Table A-II/1 and Table A-II/2 of the STCW Code. In fact, rather than addressing it in the Table A-II/2 of the STCW Code, it is better to address it in the Table A-II/1. Because in one hand, junior officers also engage in working aloft and on the other hand, if they happen to see others not following safe procedures, they can report, and the matter can be rectified immediately by themselves.

Working aloft is addressed in Table A-II/5 of the STCW Code. This is important as the ABs (deck) are allowed to work alone.

Detailed guidelines are provided in the COSWP and 'Accident prevention onboard at sea and in port' (by ILO) on working aloft.

However, as mentioned above, the MCA guidelines are not compulsorily applicable internationally. ILO guidelines are not legally binding [33] therefore not compulsorily applicable. Code adopted by the ILO is not quoted in the applicable Tables of the STCW Code other than for the PSSR programme. Where, Table A-VI/1-4 states that need to gain KUP in '*Familiarization with international measures concerning accident prevention and occupational health*' and further the Table states that '*The ILO Code of Practice on Accident prevention on board ship at sea and in port may be of assistance in the preparation of courses*'. The ILO Code of practice covers a very wide area with regard to the prevention of occupational accidents onboard ships. Therefore, different administrations may decide to cover different areas of the Code during the PSSR programme which may cause the loss of standardization of education and training. Therefore, rather than quoting the whole Code, the areas that should be familiarized are required to be listed in the Column 2 of the Table. When these are listed, the duration of the programme also can be determined by the Authorities easily.

Other than the flag states legislations like COSWP there are no internationally compulsory legislations with regard to working aloft. With regard to safe working aloft, SOLAS requires [43] to have safe access to cargo holds, cargo tanks etc. but that is also for the purpose of close-up inspections and thickness measurements of the ship's structures only, and not for other operations. Therefore, need to consider of having international regulations concerning safe working aloft.

Since this is a serious problem not only with cargo related operations but also during maintenance work onboard, IMO should consider of developing procedures for safe working aloft.

Since developing of legislation may take some time, safety while working aloft also can be addressed during the above awareness programme on entering enclosed spaces to get the attention of the seafarers.

f) Prevention of accidents while climbing up/down

No IMO documents address the preventive measures to be observed while climbing up/down ladders. During this 5 year period all the accidents which had happened while climbing up or down were taken place while using fixed vertical ladders, specially, the cargo hold access ladders.

This should probably be addressed through the ILO Code of practice or the COSWP. In fact, both of these documents address precautions to be observed while using portable ladders but not

fixed vertical ladders. The precautions to be observed while climbing vertical ladders may include;

- Carryout a risk assessment
- Use of proper PPE (gloves, safety helmet with chin strap on, safety harness, fall arrester device, safety shoes)
- To have situational awareness
- Keep both hands free [44]
- Only one person must use a ladder at a given time
- Use three points of contact [45]
- Do not run on the ladders
- Face the ladder and use both hands to hold the rungs firmly [45]
- Place feet firmly on each rung [45]
- Check the footing before descending a ladder [45]

Use of a fall preventer device while climbing vertical ladders is not an international requirement. It is better to consider making it compulsory to use a fall preventer while climbing vertical ladders which are at least over a certain height.

The industry needs to promote the use of 'three-point contact' in the maritime sector. At the moment, this is practiced only by some ship owners but not all. Better to have a common safety sticker (as below) posted, next to the vertical ladders (at the entrance and exit points both) to remind the use of three-point contact:

Three-point contact sticker [46]

Figure - 2

This sort of a sticker will remind not only the seafarers to use three-point contact, but also the port workers to enhance their safety.

It is better to remind again, that this research is based only on accidents related to cargo and cargo related operations. There were similar types of accidents which were incurred during maintenances as well. Therefore, it is worth considering making the use of a fall preventer device mandatory at least if the vertical ladders are above a certain height.

Table A-VI/1-4 (PSSR Programme) of the STCW Code should be amended to include the three-point contact and other safety measures to be observed while climbing fixed vertical ladders.

In order to reduce the risks involved with climbing vertical fixed ladders immediately, above mentioned awareness campaign (on entering enclosed spaces and working aloft) may include safe procedures in climbing vertical fixed ladders.

g) Prevention of accidents by unknown nature of cargo

In accordance with the Table A-II/2 of the STCW Code chief officers ae required to gain KUP in '*ability to establish procedures for the safe cargo handling in accordance with the provisions of the relevant instruments such as IMDG Code, IMSBC Code*' etc. Procedure in handling unidentified bulk cargoes is provided in the IMSBC Code. Therefore, training and education on the carriage of unidentified solid cargoes in bulk can be considered sufficient. Carriage of unidentified or undeclared IMDG goods in package form is beyond the control of the seafarers. Therefore, it is out of the scope of this research.

The contents in the Table A-V/1-1-3 and Table A-V/1-1-2 of the STCW Code with regards to loading, segregation, taking care and discharging of chemicals and oils carried on chemical tankers and oil tankers can also be considered sufficient.

Most of these types of accidents could have been avoided if the seafarers had complied with SMS, existing codes and guidelines like the IMSBC Code, ISGOTT etc.

h) Prevention of accidents by fumigation

Out of the total of 5 accidents, the IMO 'Recommendations on the safe use of pesticides in ships applicable to the fumigation of cargo holds' [47] (issued on 27th May 2008) was not referred to in 04 occasions by the ship's staff. It was not very clear whether that was because the masters

and the chief officers were not aware of the said recommendations or whether it was ignored due to some other reason.

Apart from the above recommendations, the IMO has issued 'recommendations on the safe use of pesticides in ships' [48] (issued on 30th June 2010) which also addresses fumigation onboard to a certain extent.

STCW Code does not directly specify that the chief officers and masters should have sufficient knowledge on fumigation on board. But, it provides broader topics which cover wide areas. Following are the KUP that is required to be gained by the chief officers and masters in accordance with the STCW Code where the 'fumigation' could be accommodated:

i. *Knowledge of and ability to apply relevant international regulations, codes and standards concerning the safe handling, stowage, securing and transport of cargoes* [49] and
ii. *Ability to establish procedures for safe cargo handling in accordance with the provisions of the relevant instruments such as IMDG Code, IMSBC Code, MARPOL 73/78 Annexes III and V and other relevant information* [49]

There is no deference between the STCW'78 as amended in 1995 and Manila amendments with regard to this effect except the STCW'78 as amended in 1995 refers to the BC Code instead of the IMSBC Code.

Chief mate and master candidates are required to have a good knowledge on the IMSBC Code in accordance with the Table A-II/2 of the STCW Code. Above mentioned IMO 'Recommendations on the safe use of pesticides in ships applicable to the fumigation of cargo holds' (MSC. 1/Circ.1264) is included in the IMSBC Code as well. Therefore, one may argue that the 'fumigation' is addressed sufficiently by the STCW Code.

After examining the number of accidents and the in-depth analysis of the accident investigation reports, it is doubtful whether the Administrations and the approved maritime training institutes have included education on fumigation into their curriculums.

Because of the risks involved with fumigation (and enclosed spaces as mentioned above), it is better to consider amending above h(ii) as below:

Ability to establish procedures for safe cargo handling in accordance with the provisions of the relevant instruments such as IMDG Code, IMSBC Code, MARPOL 73/78 Annexes III and V and other relevant information such as but not limited to information on fumigation, enclosed spaces etc.

i) Prevention of accidents by fire/Explosion

In accordance with the Table A-II/2 of the STCW Code, chief officers shall be *able to establish procedures for safe cargo handling in accordance with the provisions of the relevant instruments such as IMDG Code, IMSBC Code, MARPOL 73/78 Annexes III and V and other relevant information*. Since the carriage of coal is sufficiently elaborated in the IMSBC Code, the training and education with regard to the prevention of coal fires/explosion could be considered sufficient.

The tank cleaning operations onboard tankers are conducted under the direct supervision of the chief officer. Table A-II/2 of the STCW Code requires only to gain general knowledge of tankers and tanker operations. But chief officers are required to obtain Certificate of Proficiency in advanced training for oil or chemical tanker cargo operations to sail on relevant tankers. Table A-V/1-1-2 and Table A-V/1-1-3 of the STCW Code covers sufficient KUP that is required to carry out chief officer's duties onboard respective tankers.

At the same time, those who are sailing in the support level are required to possess a Certificate of Proficiency in basic training for oil and chemical tanker cargo operations. Table A-V/1-1-1 of the STCW Code covers sufficient KUP that must be gained in obtaining this certificate.

Therefore, the prevention of fires and explosions can be considered to be sufficiently addressed in the relevant Tables of the STCW Code.

Apart from maintaining a good situational awareness, strict compliance with the legislative requirements, shipper's requirements and SMS is necessary to avoid these types of accidents.

j) Prevention of accidents due to improper maintenance

Accidents that occur due to improper maintenances can be avoided by adhering to the Planned Maintenance System (PMS) onboard and by rectifying the reported and noticed damages.

The STCW Code, does not directly address the PMS, but in accordance with the Table A-II/2 of the Code, chief officers shall gain KUP in;

- *responsibilities under the relevant requirements of the International Convention for the Safety of Life at Sea, 1974, as amended* (SOLAS as amended) and
- *responsibilities under international instruments affecting the safety of the ship, passengers, crew and cargo*'

the International Safety Management (ISM) Code was implemented through SOLAS. Which means the PMS is addressed in the STCW Code. At the same time, PMS is maintained onboard all cargo ships of 500 GT or more engaged in international trade. Which means, junior officers will be having knowledge about PMS well before becoming chief officers. Therefore, training and education for chief officers with regards to the maintenance of the deck department can be considered sufficiently addressed.

The other means of avoiding accidents due to improper maintenance is by rectifying the damages once they are reported or noticed. Even though the deck is maintained in accordance with the PMS, a vessel may encounter damages due to various other operations such as cargo operations, vibrations, bad weather conditions etc. To ensure these damages are reported, the operational level deck officers and the ratings are required to have sufficient knowledge in identifying them.

In accordance with the Table A-II/1 of the STCW Code, the officers at the operational level should be competent enough to '*Inspect and report defects and damage to cargo spaces, hatch covers and ballast tanks*'. Therefore, the training of operational level officers with regard to corrosion, damages, wear and tear can be considered sufficient in the STCW Code.

More than the deck officers at the operational level, the deck ratings are working on the deck and in the cargo holds. Therefore, they should be given a basic knowledge on how to '*Inspect and report defects and damage to cargo spaces, hatch covers and ballast tanks*'. The Table A-II/5 of the STCW Code is silent with regards to this. Reporting of these kinds of defects is very important to develop a good safety culture onboard.

This type of accidents could have been avoided if PMS, SMS and the manufacturer's instructions were complied with.

k) Prevention of accidents by cargo shift/liquefaction

Again, chief officers and masters should have sufficient KUP in '*establishing procedures for the safe cargo handling in accordance with the provisions of the relevant instruments such as IMDG Code, IMSBC Code, MARPOL 73/78 Annexes III and V and other relevant information*' [49].

The IMSBC Code provides comprehensive guidelines on what cargoes are liable to liquefy if carried with a moisture content higher than the Transportable Moisture Limit (TML), how to roughly check the moisture content onboard, actions that a master should take if he suspects that the moisture content is higher than the TML and trimming procedures for cargoes having different angles of repose etc.

When considering the mandatory sea experience required to be eligible to sit for the chief officer and master examinations and the above KUP that is required to be gained, may be considered that the training & education to avoid accidents due to cargo shift/liquefaction is effective and sufficient for chief officers and masters.

Strict compliance with the legislative requirements, shipper's requirements and SMS is necessary to avoid this type of accidents.

l) Prevention of accidents due to cargo lashing failures/improper lashing

In accordance with the Table A-II/2 of the STCW Code chief officers and masters are required to have KUP on '*loading and unloading operations, with special regard to the transport of cargoes identified in the Code of Safe Practice for Cargo Stowage and Securing*'.

The purpose of the above 'Code of Safe Practice for Cargo Stowage and Securing' (CSS Code) is to provide an international standard to promote the safe stowage and securing of cargoes by, inter alia, providing advice to ensure that the ship is equipped with proper cargo securing means, providing general advice concerning the proper stowage and securing of cargoes to minimize the risks to the ship and personnel and advising on actions which may be taken in heavy sea conditions [50]. While the CSS Code provide generic actions to be taken to ensure proper cargo stowage and securing, the CSS Code addresses the Cargo Securing Manual that is required to be carried onboard in accordance with the IMO circular [51]. This is the ship specific document related to cargo securing. Therefore, training and education of chief officers with regard to cargo stowage and securing can be considered to be sufficiently covered by the STCW Code.

According to The Swedish Club [52], most common reasons for container losses are, among other things:

- Containers not being loaded as per the stowage plan
- Containers not secured in accordance with the Cargo Securing Manual (CSM)
- Lashing strengths not checked against the loading computer's lashing module
- The vessel being too stiff with an excessive GM (Metacentric Height)

Loading computers on the container vessels have the facility to check the lashing strengths and this is not addressed by the Table A-II/2 of the STCW Code. With regards to the loading computer, the said Table states "*use of stability and trim diagram and stress-calculating equipment, including automatic data based (ADB) equipment, and knowledge of loading cargoes and ballasting in order to keep hull stress within acceptable limits*". This KUP refers to stresses on the ship's hull but not on the container securing. Therefore, amending the table to include 'lashing strengths' on container ships must be considered.

As the container losses at sea is a growing problem, the stakeholders should consider of carrying out an awareness campaign between all the parties and senior management of the floating staff to eliminate other problems which were mentioned above to reduce container losses.

Parametric rolling is a phenomenon that particularly affects larger vessels with flared fore and aft decks such as Container ships and Pure Car/Truck Carriers (PCTC) [53]. Cargo losses due to parametric rolling is a serious problem onboard large container vessels. According to the World Shipping Council parametric rolling motion contributes to loss of around 1000 containers a year [54]. The risk involve will continue to increase with the increasing size of the container ships as well. In accordance with the Table A-II/2 of the STCW Code masters and the chief officers shall have KUP in '*characteristics of various weather systems, including tropical revolving storms and avoidance of storm centres and the dangerous quadrants*'. It is doubtful to say that the parametric rolling is covered by this KUP. Because;

- Parametric rolling cannot be considered as a so called '*weather system*'. It is a phenomenon and this could also occur not only during heavy weather but also during moderate seas.
- The rest of the above KUP addresses the tropical revolving storms

Therefore, administrations may not have included the parametric rolling into their curriculums. In order to avoid this misunderstanding, it is better to amend the Table A-II/2 of the STCW Code to include 'forecasting and avoidance of parametric rolling'. Otherwise, it is better to consider quoting the IMO's guidance in 'avoiding dangerous situations in adverse weather' [55] in the same Table of the STCW Code, so that not only the parametric rolling but, other dangerous situations will be covered as well.

Shipowners voluntarily use software systems to facilitate the master and the navigating officers in re-routing the vessel to avoid dangerous situations. At present, carriage of such software is not mandatory in accordance with the International Convention for the Safety of Life at Sea (SOLAS). Therefore, training on such systems has not been made mandatory by the STCW Code. Due to the risks involved, IMO should consider making it mandatory to carry such systems on applicable (container ships above certain tonnage) ships. At the same time, KUP in using such systems should be made mandatory through the STCW Code for those who are sailing on applicable ships.

Apart from phenomenon like parametric rolling, ships encounter heavy weather conditions frequently and it is a problem for ships of all types and sizes. The company SMS may state to avoid certain sea conditions to avoid damages. This could be done only when the weather predictions are correct. If the predictions are not correct, they might, probably end up with a sea condition beyond the limits mentioned in the SMS. Capt. Takuzo [56] states that although the

precise prediction of weather and sea conditions has improved over the recent years, it is still not 100% guaranteed and there could be occasions where weather and sea conditions fell outside of master's prediction. Therefore, KUP in ship handling during heavy weather is very important to reduce accidents.

In accordance with the Table A-II/2 of the STCW Code, masters are required to have KUP in "*management and handling of ships in heavy weather, including assisting a ship or aircraft in distress; towing operations; means of keeping an unmanageable ship out of trough of the sea, lessening drift and use of oil*". In accordance with the column 3 of the Table, this KUP could be obtained either by;

- *approved in-service experience or*
- *approved simulator training, where appropriate or*
- *approved manned scale ship model, where appropriate*

Deck officers used to gain this KUP through approved in-service experience rather than approved simulator training.

Which means, so far, ship handling in heavy weather conditions was learnt by seeing how the seniors were doing it and by own experience. Now it is the time to consider making it mandatory to have simulator training programmes to train senior officers onboard in ship handling during heavy weather conditions.

m) Prevention of accidents due to noncompliance with ship's stability

During the five-year period concerned, only two accidents had taken place due to not complying with required stability criteria. In one of the cases, the chief officer had sufficient experience with the type of the vessel and the accident took place not due to any miscalculation of stability but, because he had not checked the actual stability condition of the vessel before departure. Even though the vessel became unstable after the completion of loading due to a chain of errors, if he managed to assess the ship's stability before departure, he could have rectified the matter. Therefore, this accident had taken place due to the loss of situational awareness of the chief officer rather than due to his incompetency.

In the case of the other incident, the chief officer had good experience as a chief officer but not with this type of vessels. Therefore, again, it is difficult to say that he was not aware of how to check the stability condition of the vessel. Probably, again, rather than the incompetency, the lack of situational awareness led to the accident.

In accordance with the Table A-II/2 of the STCW Code, chief officers and masters are required to be competent in '*Control trim, stability and stress*'. This competency can be considered sufficient to conduct duties as a chief officer with regard to ship's stability.

This type of accidents could have been avoided if the actual stability condition was assessed before departure, maintained a good situational awareness and complied with the ship's SMS.

n) Prevention of accidents due to contact with liquid cargoes

Apart from the 'Basic safety training' certificates, the pumpmen are required to have only the 'Basic training for oil and chemical tanker cargo operations' (in accordance with the Table A-V/1-1-1) certificate. This Table states that the holders are required to have KUP in;

- *Proper use of safety equipment and protective devices, including* among other things, *protective clothing and equipment*
- *Basic knowledge of safe working practices and procedures in accordance with legislation and industry guidelines and personal shipboard safety relevant to oil and chemical tankers, including* among other things, *precautions to be taken before and during repair and maintenance work*

At the same time, PSSR programme requires to gain KUP in;

- *Importance of adhering to safe working practices at all times*
- *Safety and protection devices available to protect against potential hazards aboard ship*

It is not very clear whether the above-mentioned basic knowledge on precautions to be taken before and during repair and maintenance work is sufficient for a pumpman as they are required to conduct more advanced duties onboard. Whether this certification to work as a pumpman is sufficient or not, to avoid injuries due to contact with liquid cargoes, can be considered sufficiently addressed by the STCW Code.

o) Prevention of cargo overflows

An oil overflow took place during loading cargo while the duty officer was controlling the cargo operations. It is not very clear whether he had 'Basic training for oil & chemical tanker cargo operations' certificate or 'Advanced training for oil tanker cargo operations' certificate? If he was holding the basic training certificate, he was having only a basic knowledge in cargo operations and pollution prevention matters. In that case, he should not have been allowed to monitor the cargo operations alone.

If he was holding the advanced training certificate, the accident might have occurred due to the lack of situational awareness or incompetency. Because the training and education required to obtain advanced training certificate can be considered sufficient.

p) Additional certification

Risk has two elements, the likelihood that a hazard may occur and the consequences of the hazardous event [44]. Therefore:
Risk = Likelihood x Consequences

Which means, the risks will be high when:

- the number of accidents of the same type are higher; or
- the consequences due to an accident is high

When comparing the cargo work related operations onboard bulk carriers and tankers, the risk on tankers is high since the 'Consequences' are high. Since most of the cargo related accidents have taken place onboard bulk carriers, the risk on bulk carriers is high because the 'Likelihood' is high.

Therefore, now it is the time to consider whether additional training and certification is required to sail on bulk carriers similar to the additional training and certification which is required to sail on tankers.

q) Circulation of accident investigation reports

Usually, the companies send circulars to the other vessels within the fleet after an accident occurs onboard a ship. This helps in re-thinking about the safety onboard, because when routine work is carried out without any incident, the importance of the safety may fade away from the minds of the seafarers. This could be the reason for most of the accidents which had happened when the injured person and the person in charge both were having sufficient experience with the rank. Therefore, it is better, if the flag state can send the accident investigation reports to all the companies or if the companies can download these accident investigation reports from their respective flag state's websites or GISIS and share with their fleet and the officers who are on leave.

Masters should be encouraged to discuss the accident investigation reports during safety committee meetings rather than keeping the reports in the salon or the mess room of the vessel for the seafarers to read on their own.

r) Toolbox meetings onboard

As a final precautionary measure, masters and the chief officers should be encouraged to address/remind the following during every toolbox meeting until the risk is eliminated or lowered:

- A list of enclosed spaces in the respective working areas onboard
- Not to enter enclosed spaces without following the safety procedures
- Not to enter but to raise the alarm if an emergency arises in an enclosed space
- Use of appropriate PPE
- Safe use of fixed vertical ladders (when applicable)
- Safe working aloft procedures (when applicable)
- Maintaining a good situational awareness throughout the operation
- To inform the chief officer or the duty officer in case of any changes in the working environment

16. Summary of suggestions

16.1 Safety management system (SMS) onboard

a) Since internationally accepted codes and guidelines are required to develop a good SMS;
   - 'Accident prevention onboard ship at sea and in port' (published by ILO) shall be updated frequently in accordance with the regulatory changes or
   - Need to consider of accepting COSWP (published by MCA, UK) internationally

b) IMO should consider whether SMS must be an approved system by a competent authority or recognized organization subjected to master's reviews periodically.

c) Companies must encourage their masters to review the SMS effectively and proactively.

d) Compulsory SMS reviews shall be carried out during the internal ISM audits both by the master and the internal auditor.

e) Companies and the senior management onboard shall concentrate more on proactively implementing the SMS onboard and maintaining a safety culture always.

f) If the SMS is amended, it must be conveyed to masters and deck officers on leave, so that, they can be updated themselves about the changes before going onboard again.

g) Publicity shall be given to best practices used by flag states and ship owners, so that other shipowners also can implement them.

h) IMO should consider making it compulsory to report both near misses and 'unsafe practices' to the company. The company shall analyze these near misses and unsafe practices effectively and proactively to identify the risks involved. Analyzing of near misses and unsafe practices shall be audited during the ISM audits of the company.

i) Port states, flag states, ship owning companies should consider of having awareness programmes to seafarers to make them understand the importance of complying with the SMS, most suitably with the aid of case studies.

16.2 Safety of port workers

a) Need to have a mechanism to circulate accident investigation reports involving port workers between the ports around the world. This experience transfer will enable the port authorities to evaluate the risks and take proactive measures.

b) They shall be educated to understand the basic safety onboard, including, dangers involving enclosed space entries, actions to be taken in case of emergency in an enclosed space.

c) They shall be instructed to read safety checklists offered by the ships, make sure it is well understood and sign the checklist.

d) Above safety information shall be passed to the other port workers before the commencement of the cargo operations. Which means, they are also required to have a sort of a 'toolbox meeting' before the commencement of the operation.

16.3 Suggested amendments to the STCW Code

a) Table A-VI/1-4 (PSSR Programme) of the STCW Code shall be amended to include:
- Obtaining and maintaining situational awareness.
- Safety measures to be observed while climbing fixed vertical ladders.
- Rather than mentioning broad areas on this Table such as '*Familiarization with international measures concerning accident prevention and occupational health'*, areas to be covered must be pinpointed on the Table. This will enable to standardize the KUP of those who are following the programme and standardize the duration of the programme throughout the word.

b) Table A-II/1 (OOW on ships of 500 GT & above, unlimited) of the STCW Code shall be amended to include:
- Knowledge in safe operations of cargo lifting appliances
- Knowledge in safe working aloft procedures

c) Table A-II/2 (Masters and chief mates on ships of 500 GT & above, unlimited) of the STCW Code shall be amended to include:
- Enclosed space entry procedures.
- Safe use of fumigants.
- Use of lashing software on container ships.
- IMO's guidance in avoiding dangerous situations in adverse weather.
- Knowledge of using software systems to facilitate the master and the navigating officers re-routing of the vessel avoiding dangerous situations if the carriage of such systems made mandatory.
- Simulator training for ship-handling in heavy weather.
- Knowledge on developing, implementing and maintaining a safety culture onboard.

d) Table A-II/5 (Ratings as able seafarer deck) of the STCW Code shall be amended to include:
- Basic knowledge in risk assessment.
- Basic knowledge in inspecting and reporting defects and damage to cargo spaces and hatch covers.

16.4 Other areas to consider

a) Onboard training on risk assessment to be provided to the deck officers and ratings who were certificated before the Manila amendments to the STCW Convention.
b) Onboard training on maintaining situational awareness shall be provided to deck officers and ratings who obtained certificates prior to Manila amendments to the STCW Convention.
c) Industry shall consider of prohibiting the use of mobile phones during cargo operations other than for ship's matters.
d) Existing codes (on safe practices) and safe operating procedures with regards to freight vehicles shall be amended to include, 'The signalman must not lose the eye contact with the driver (dierctly or through mirrors) until the vehicle is parked, brakes applied and engine stoped'.
e) IMO, flag states, port states and other stakeholders should consider of arranging a world wide awareness programme with regards to high casualties due to enclosed space entries. This could be done by emails and social media to reduce costs.
f) A drill or a refresher drill on enclosed spaces shall be made mandatory within specified number of days (example – within a week) after joining a vessel specially on tankers and bulk carriers.
g) Internationally accepted safety sticker shall be introduced to post at the entrances to enclosed spaces onboard. This will enable not only the seafarers but also the port workers to identify enclosed spaces.
h) Internationally accepted legislation and procedures shall be developed for safe working aloft. Until then, could have awareness campaigns to educate the seafarers with regard to safe working aloft procedures.
i) Internationally accepted safe procedures are required to be developed for using fixed vertical ladders. Safety stickers shall be posted at the entrance and exit points of the fixed ladders to remind to use 'three-point contact'. Awareness programmes may be conducted by flag states and shipowners to raise the awareness of safe use of fixed vertical ladders.
j) IMO should consider of making mandatory to carry software systems to facilitate the masters and the navigating officers re-routing of the vessel avoiding dangerous situations onboard above certain tonnages of container ships.
k) Need to assess the certification requirements to sail onboard bulk carriers similar to the additional certificates required to sail on tankers.
l) Flag states and the shipping companies must circulate accident investigation reports (issued by their own flags and other flags) onboard their ships, encouraging masters to discuss the reports during safety committee meetings.
m) Until the present likelihood of the risks are reduced, companies shall encourage their masters and chief officers to address certain safety elements during every toolbox meeting.

17. Conclusions

Even though after the implementation of the ISM Code and various other initiatives taken by IMO, ILO, port states, flag states, shipowners and seafarers, safety onboard has increased considerably, accidents onboard ships are still continuing. Time to time, need to carryout in depth analysis of these accidents in order to identify the new issues with the existing systems, new training needs of seafarers, high risk areas and preventive measures.

One fourth of the accidents occurred on ships of 500 GT and above engaged in international voyages (among the said flag states considered) were due to cargo work related operations. This indicates that the risks in cargo related operations is still high. Gaps between the existing training/certification requirements and competencies which are required to work onboard still exists and need to take further immediate measures to enhance the safety onboard.

Based on the outcomes of this research, various suggestions are made as described above. As some of the suggestions may take some time to implement, shipowners and flag states need to consider of adhering to the other suggestions which may be followed by them. As an example, having awareness campaigns in order to reduce accidents during enclosed space entries, working aloft and climbing up/down fixed vertical ladders. During this research, it was identified that these kinds of accidents have taken place not only during cargo related operations but also during other operations carried out by both deck and engine staff. Therefore, compliance with the recommended suggestions will ensure the safety of both departments while engage in cargo related operations as well as maintenance operations.

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