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Subject: "Health and Safety during the travel of a cargo ship"

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Abstract

Nowadays Health and Safety is one of the most crucial priorities in every industry. The maritime industry has a perhaps the unique characteristic of involving physical risk. Between nations and organizations, there is a common need to create a safe and viable environment in sea transports and minimize any hazardous operations that can affect the next generations and the sustainability of our planet in global scale. This thesis is trying to point out common dangers as well as the procedures against hazards during the travel of a ship's sail. Also includes the negative effects that they may have on humans and pollutant operations that have to be taken into consideration. Sea transports play a vital role since around 90% of the world's trade is carried by the international shipping industry. Thus, further elaboration on the factors that contribute to such procedures should be taken into consideration in order to achieve great results. Human and environmental safety, are the two main pillars that are governing this field of studies and therefore they are the pivot point for all actions taking into account.

Keywords: Health, Safety, ship accident, ship hazards, danger, environmental pollution, firefighting, human factor, shipping, safety regulations

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Abstract in Greek

Σήμερα το θέμα της Υγείας και Ασφάλειας αποτελεί μία από τις πιο κρίσιμες προτεραιότητες σε κάθε χώρο εργασίας. Η ναυτιλιακή βιομηχανία έχει ίσως το μοναδικό χαρακτηριστικό της συμμετοχής των φυσικών κινδύνων λόγο του θαλάσσιου περιβάλλοντος. Μεταξύ εθνών και οργανισμών, υπάρχει μια κοινή ανάγκη για τη δημιουργία ενός ασφαλούς και βιώσιμου πλαισίου στις θαλάσσιες μεταφορές και την ελαχιστοποίηση των επικίνδυνων ενεργειών που μπορεί να επηρεάσουν τόσο επόμενες γενιές όσο και τη βιωσιμότητα του πλανήτη μας. Η εργασία αυτή προσπαθεί να εντοπίσει τους κύριους κινδύνους καθώς και τις διαδικασίες εναντίον αυτών όταν το πλοίο βρίσκεται εν πλω. Περιλαμβάνει επίσης τις αρνητικές επιπτώσεις που μπορεί να έχουν στον άνθρωπο και ρυπογόνων λειτουργιών που πρέπει να ληφθούν υπόψη. Οι θαλάσσιες μεταφορές έχουν ζωτικό ρόλο δεδομένου ότι περίπου το 90% του παγκόσμιου εμπορίου μεταφέρεται από τη διεθνή ναυτιλιακή βιομηχανία. Έτσι, θα πρέπει να δοθεί περαιτέρω έμφαση στην ανάλυση των επιμέρους παραγόντων που συμβάλλουν στην διεκπεραίωση των διαδικασιών αυτών προκειμένου να επιτευχθούν τα καλύτερα δυνατά αποτελέσματα. Ανθρώπινη και περιβαλλοντική ασφάλεια, είναι οι δύο βασικοί πυλώνες που διέπουν αυτό το πεδίο των μελετών και ως εκ τούτου αποτελούν τον πυρήνα για όλες τις δράσεις που λαμβάνουν χώρα.

Λέξεις-κλειδιά: Υγεία, ασφάλεια, ναυτικό ατύχημα, κίνδυνοι στο πλοίο, ρύπανση του περιβάλλοντος, πυρόσβεση, ανθρώπινος παράγοντα, ναυτιλία, κανονισμοί ασφαλείας

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Summary in Greek

Η ναυτιλία είναι μια διεθνής βιομηχανία που ενεργεί, επηρεάζεται και επηρεάζει σε παγκόσμιο επίπεδο. Από τα πρώιμα στάδια ακόμη, πριν εξελιχθεί στο επίπεδο που είναι σήμερα διάφορες τακτικές και κανόνες άρχισαν να εφαρμόζονται ώστε να επιτευχθεί ένα επιθυμητό επίπεδο ασφάλειας και βεβαίως οι πρωτεργάτες αυτής της κίνησης ήταν άνθρωποι που είχαν στενή σχέση με την θάλασσα και τα καράβια όπως για παράδειγμα οι λιμενικές αρχές και έμποροι που μετάφεραν αγαθά στις διάφορες περιοχές. Στις μέρες μας επιφορτισμένος με τέτοιες εργασίες είναι ο IMO (International Maritime Organization) καθώς και ένα πλήθος άλλων οργανισμών οι οποίοι προσπαθούν να δημιουργήσουν μεθόδους και διαδικασίες για να αντιμετωπιστούν τυχόν προβλήματα ή κίνδυνοι που θα παρουσιαστούν στην ζωή του πλοίου.

Οι εμπλεκόμενοι με τον ναυτιλιακό τομέα είναι πολλοί και όπως είναι φυσικό αντικρουόμενα συμφέροντα υπάρχουν μεταξύ των διαφόρων συντελεστών. Η ασφάλεια των θαλασσίων μεταφορών είναι ένα θέμα που αφορά τον καθέναν από αυτούς και η στάση που παρουσιάζουν πάνω στο θέμα αυτό εν τέλη καθορίζει και το επίπεδο ασφάλειας της ναυτιλίας. Οι κυβερνήσεις των χωρών είναι ο βασικός κρίκος μεταξύ των οργανισμών που μεριμνούν για την ασφάλεια των πλοίων και το ισχύον νομικό πλαίσιο. Νηογνώμονες και λιμενικές αρχές είναι επιφορτισμένοι με τον έλεγχο της ορθής εφαρμογής των κανονισμών ασφάλειας. Κανονισμοί και οδηγίες μπορούν πάντοτε να παραβιάζονται και έτσι είναι και ευθύνη των ναυπηγείων και των ναυτιλιακών εταιριών να ακολουθούν μια πολιτική η οποία έχει ως γνώμονα την ασφαλή λειτουργία των πλοίων.

Τα πλοία δραστηριοποιούνται σ' ένα ιδιαίτερα επικίνδυνο και απρόβλεπτο περιβάλλον και κανόνες έχουν θεσπιστεί τόσο για τα χωρικά όσο και για τα διεθνή ύδατα. Κομβικά σημεία όπως φυσικά ή τεχνητά περάσματα συγκεντρώνουν την πλειοψηφία των ταξιδιών των πλοίων και συνεπώς επιπλέον τοπικοί κανονισμοί ασφάλειας οφείλουν να πληρούνται από κάθε πλοίο που σκοπεύει να χρησιμοποιήσει αυτές τις οδούς.

Μελετώντας τους επιμέρους τύπους πλοίων καθώς και τα ατυχήματα τα οποία έχουν συμβεί είναι δυνατόν να εντοπιστούν οι πιο συνήθεις αιτίες στις οποίες οφείλονται τα ναυτικά ατυχήματα. Ο κάθε τύπος πλοίου έχει τις δικές του ιδιαιτερότητες που οφείλονται κυρίως στο τύπο του φορτίου το οποίο μεταφέρουν. Ένα από τα μείζονος σημασίας μεταφερόμενα φορτία είναι το πετρέλαιο και τα παράγωγα του που ταξιδεύουν μέσω θαλάσσης ώστε να καλύψουν τις ενεργειακές ανάγκες του πλανήτη. Η κατανόηση των κινδύνων που ενέχει η μεταφορά τέτοιου είδους φορτίων ενισχύει την αποφυγή ατυχημάτων και την ασφαλέστερη μεταφορά αυτών.

Εκτός από τα επικίνδυνα φορτία ο εργαζόμενος πάνω στο πλοίο βρίσκεται αντιμέτωπος με ασθένειες που αν δεν τους δοθεί η απαραίτητη προσοχή ενδέχεται να θέσουν σε σημαντικό κίνδυνο την υγεία του ναυτικού. Γνώση και πρόληψη είναι σε πολλές των περιπτώσεων είναι η μόνη άμυνα καθώς η θεραπεία κρίνεται πολλές φορές ανεπαρκής.Η καθημερινότητα στο ταξίδι ενός εμπορικού πλοίου είναι άρρηκτα συνδεδεμένη με μια πληθώρα κινδύνων που οφείλονται είτε στην κανονική ροή των εργασιών είτε σε κρίσιμα συμβάντα που εμφανίζονται κατά την λειτουργία των πλοίων.

Ένα νομικό πλαίσιο έχει θεσπιστεί από τους αρμόδιους μηχανισμούς ώστε να καλύψει τρία κυρίως βασικά ζητήματα: την προστασία της ανθρώπινης ζωής στην θάλασσα, την προστασία του περιβάλλοντος και το ζήτημα των αποζημιώσεων σε περίπτωση ατυχούς συμβάντος.

Αναμφισβήτητα οι κανονισμοί έχουν βοηθήσει στην βελτίωση των συνθηκών κάτω από τις οποίες λειτουργούν οι θαλάσσιες μεταφορές τίθενται όμως κάποιες αμφιβολίες για το κατά πόσο αποτελεσματικά πετυχαίνουν τον αρχικό τους στόχο και το κατά πως η αργοπορία ένταξή τους στους νόμους της κάθε χώρας υποβαθμίζει το επίπεδο ασφάλειας.

Πιο πολύ σήμερα παρά ποτέ άλλοτε, γίνεται αντιληπτή η σημασία της ρύπανσης του περιβάλλοντος καθώς έχει σημαντικό αντίκτυπο στην ανθρώπινη υγεία. Η ρύπανση των υδάτων καθώς και η ρύπανση του ατμοσφαιρικού αέρα είναι οι δύο κύριες ενότητες που αφορούν την ρύπανση του περιβάλλοντος από την δραστηριότητα των πλοίων και συνεπώς βρίσκονται και στο στόχαστρο των κανονισμών ασφάλειας.

Όπως έχει ήδη αναφερθεί η ανάπτυξη μεθόδων και κανονισμών μετρά πολλά χρόνια πίσω στις αρχές του θαλασσίου εμπορίου και συνεπώς οι περισσότερες αν όχι όλες οι ενέργειες που σχετίζονται με τα ταξίδια στην θάλασσα διέπονται από ένα πυκνό πλαίσιο κανονισμών. Ο ανθρώπινος παράγοντας και η πιθανότητα του ανθρωπίνου λάθους αποτελεί ακόμη αντικείμενο βελτιστοποίησης και για αυτό το λόγο αποτελεί και την βασική αιτία πίσω από την πλειοψηφία τον ατυχημάτων.

Η φωτιά αν και αποτελεί εκτενές αντικείμενο μελέτης πολλών από τους κανονισμούς ασφάλειας συνεχίζει να αποτελεί βασικό αίτιο ατυχημάτων στα πλοία. Ο αμυντικός εξοπλισμός, είτε είναι μέρος της κατασκευής του πλοίου συνδυασμένος με μια σειρά αυτοματισμών για γρηγορότερη απόκριση, είτε είναι σχεδιασμένος ώστε να χρησιμοποιηθεί από το πλήρωμα. Διαφορετικά συστήματα και εξοπλισμοί χρησιμοποιούνται για διαφορετικού τύπου πυρκαγιές για βέλτιστο αποτέλεσμα.

Ο εξοπλισμός πάνω στα πλοία μπορεί να προορίζεται για ομαδική χρήση όπως είναι για παράδειγμα οι σωσίβιες λέμβοι εκκένωσης . Υπάρχει ακόμη ατομικός εξοπλισμός που παρέχει την απαραίτητη προστασία για καθημερινές επικίνδυνες εργασίες πάνω στο πλοίο ή άλλες ειδικές περιπτώσεις όπως εκκένωση του και πυρκαγιές.

Λόγω του ότι η πρόληψη είναι λιγότερο επώδυνη διαδικασία από την αποκατάσταση, προληπτικά μέτρα λαμβάνονται ώστε να να μειώνονται ή δυνατών να αποφεύγονται δυσάρεστες καταστάσεις. Ο εμβολισμός για τις συνήθεις αρρώστιες που συναντώνται σε διάφορες περιοχές είναι υποχρεωτικός και ένα σύνολο από σχολεία και ασκήσεις στοχεύουν στο ότι σε περίπτωση ανάγκης το πλήρωμα θα είναι σε θέση να ανταποκριθεί πλήρως στις απατήσεις και κατά το μέγιστο δυνατόν θα αποφευχθεί ή θα αντιμετωπιστεί με επιτυχία ένα ατυχές συμβάν.

Contents

List of figures

List of Tables

Terms and abbreviations

Accident: is an unexpected incident that occurs and has undesirable effects, an unusual incident that occurs for unknown reasons, or an unpredicted result of a formal procedure.

AGGIH: American Conference of Governmental Industrial Hygienist

BMPs: Best Management Practices

Classification society: A non-governmental organization in the shipping industry, a classification society establishes and maintains technical standards for construction and operation of marine vessels and offshore structures

COW: Crude oil washing

DCP: Dry Chemical Powder

E.R: Engine Room

EEBD: Emergency Escape Breathing Device

EEDI: Energy-Efficiency Design Index

GHGs: Greenhouse gases (Carbon Dioxide, Methane Nitrous Oxide, Fluorinated gases)

GMDSS: Global Maritime Distress and Safety System

ICC: International chamber of commerce

IGS: inert gas system

IMSBC: International Maritime Solid Bulk Cargoes Code

LNG: Liquefied Natural Gas

M.O.B: Man over board

mmWG: Millimeters Water Gauge

MSDS: Material Safety Data Sheet

ODS: Ozone Depleting Substances

OOW: Officer on watch

OPRC: Oil pollution preparedness, response and co-operation

PAHs: Polycyclic aromatic hydrocarbons

PM: Particulate Matter (a mixture of solid particles and liquid droplets found in the air)

PPE: Personal protective equipment

PPM: Parts per million

PSSA: Particularly Sensitive Sea Area

SCBA: Self Contained Breathing Apparatus

Sea accident: an accident that includes losses of human life or economic

SEEMP: Ship Energy Efficiency Management Plan

THC: Total hydrocarbons

TLV: Threshold Limit Value

U.N. United nations: an organization created after War II on 24 October, 1945

Vaporization: Conversion of a substance from liquid to vapor

VOC: Volatile Organic Compounds

VOCs: Volatile organic compounds

DRI: Direct reduced iron (a form of iron that it is produced through processes that reduce iron oxides to metallic iron below the melting point of iron.)

1 Introduction

The truth about **shipping** is summarized in the following facts:

- Was and will always be a dangerous activity due to the reason that ships operate in a large, deadly and unpredictable environment.
- Allow huge amount of goods to be carried out to different port through sea in an affordable way. Without them the half world will starve and the other half will freeze.
- Is, the most environmental friendly way for commercial transport needs, compared to all other alternatives.

The ownership and the management chain of a single vessel can concern a variety of countries. A common phenomenon that occurs in respect of an operating ship is that the owner, charterers, ensures, operators and also officers and crew members are from different nationalities. The variety of flagged ships should be governed by a framework of international standards in order to provide better transports and better seas.

From the very beginning three major aspects determined the international character of the shipping industry.

- Ships operate in **international waters**. It's easy for a country to define which actions are legal or not when a ship crossing its territory. In order to avoid anarchy in high seas, a common law of the sea and minimum requirements should be respected from all competing parties. (COLOMBOS, 1967)
- Visiting **different ports,** ships faced contradictory safety rules. In addition, uncertainty inside country's legislation provokes confusions.
- The world of shipping is all about **competition.** Lack of internationalization of sea rules allows less scrupulous competitors to profit more than the others.

Accidents and major disasters led first to the consolidation of local country legislation. Then those countries conducted conferences in order to achieve global integration. Finally intergovernmental organizations took over the responsibility for global safety and environmental protection.

1.1 History review and organizations

From the ancient times, rules about safety of ships were formed in order to avoid loss of life and cargo. Usually unscrupulous shipowners preferred to overload the vessel with cargo in order to gain more beneficial freights, compromising the safety of the crew and cargo by challenging the integrity of the ship. With this simple example, it can be clearly seen how safety measurements can be part of the cornerstones of the ship's economy. Large Mediterranean ports back in the 13th century started to implement strict rules concerning the safety of a vessel such as the minimum freeboard requirement, winter sailing restrictions, even death penalties for bad seamanship. (BOISSON, 1999) Without a proper legislation framework a more "risky" ship could be more competitive than others and in that way more accidents and environmental disasters would take place. The development of organizations responsible for the design and implementation of safety precautions was a necessity in order to improve sea transportation.

Organizations concerning the shipping industry were formed mainly in local regions and countries with increased shipping activity. Through the years they took greater responsibilities and formed a more international character. Nowadays IMO is considered the most conspicuous among them. After the creation of IMCO (later renamed into IMO) in Geneva back in 1948 various international bodies have been developed. During the fifties the amount of agencies involved with the maritime safety was increased. The number as well as their influence significantly increased through the years and continue to grow until today. Some of the most important organizations are the following ones:

IMO

Created in 1948 (as IMCO renamed in 1982) IMO is an agency of United Nations focused on safety and security of shipping and confrontation of pollution by ships. Due to the international nature of shipping, ships must be under a universal model in order to operate at global scale .The international maritime organization (IMO) has developed the framework that sea transports operate. Detailed technical regulations were generated in form of conventions for the safety and protection of the marine environment. It is crucial to point out the fact that IMO is not responsible for the implementation of these safety standards in every country. The national governments which are the membership of IMO are entrusted to ensure that all the ships registered under their national flag fulfill the expectations by adopting the IMO requirements to their legislation. Since its inception, it has adopted 40 conventions and over 700 codes aimed at improving maritime safety.

ILO created in 1919 the International Labour Organization is a U.N. agency that develops policies and machinates programs to enhance decent work for all workers. ILO since its establishment has also devised many international labour standards for seafarers. In 2006 the maritime session of ILO adopted the Maritime Labour Convention. In that convention almost all the ILO standards for seafarers were unified. The MLC entered into force in 20 August 2013 and established minimum working and living standards for all seafarers.

OCIMF

The Oil Companies International Marine Forum was established in 1970 in order to cope with the public concern about marine pollution. Members of this organization are large oil companies and play a consultative role to IMO. The OCIMF also developed worldwide recognized programs such as the following once:

- Ship Inspection Report (SIRE)
- Tanker Management and Self Assessment tool (TMSA)
- Offshore Vessel Inspection Database (OVID)
- Marine terminal information system (MTIS)

ICS The International Chamber of Shipping is a voluntary organization of national shipowners' associations. It was established as long ago as 1921 and represents more than half the world's merchant tonnage. The interests of ICS cover all aspects of maritime affairs, but it is particularly active in the field of marine safety, ship design and construction, pollution prevention and maritime law. ICS has consultative status with several intergovernmental organizations, notably IMO.

IAPH The International Association of Ports and Harbors is a voluntary world-wide association of port authorities, founded in 1955. Current membership includes 230 regular and 154 associate members encompassing 77 countries. The IAPH is committed to the exchange and promotion of ideas and technical knowledge on issues of concern to those who work in ports and related industries. Its consultative status with UN and other organizations, including IMO, is a positive benefit in this regard.

IMSO (1970) The establishment of the International Maritime Satellite Organization was a result of the *Convention on the International Mobile Satellite Organization* (Inmarsat) .The main purpose, concerns the usage of space to enhance safety of life at sea and communications. IMSO operates under the auspices of IMO and his famous GMDSS includes the following features:

- transmitting ship-to-shore distress alerts (by at least two separate and independent methods)
- receiving shore-to-ship distress alerts
- transmitting and receiving ship-to-ship distress alerts
- transmitting and receiving search and rescue coordinating communications
- transmitting and receiving on-scene communications
- transmitting and receiving signals for locating
- transmitting and receiving maritime safety information
- transmitting and receiving general communications
- transmitting and receiving bridge-to-bridge communications

1.2 Shipping leaders

Shipping leaders are countries, companies, as well as other organizations that are managing a bigger "slice of the pie" of the shipping industry compared to other stakeholders. The fact that their actions and decisions can affect significantly the majority of aspects in ship transports Health and Safety of shipping incurring them with greater liability.

1.2.1 Countries

It is well known that the Greek-owned merchant fleet is the biggest in the world with respect to the deadweight. In the top list Japan, China, South Korea, and Germany are considered to be the major players in the sea transports. According to the financial newspaper "Naftemporiki" Details for the world's biggest merchant fleets are illustrated in Table 1.By ship type Greece is listed first in Tankers and second in bulk Carriers (regards to the DWT).

Table 1 Merchant Fleet

Country	Number of vessels	DWT	GRT
1. Greece	4,894	291,735,318	168,922,455
2. Japan	8,357	242,640,509	159,401,728
3. China	6,427	190,601,765	116,675,336
4. South Korea	4,197	126,355,373	95,052,148
5. Germany	2,651	83,534,652	52,870,979

*Data taken in 2014 may have small variations due to dismantling and new building orders

Organizations that are entrusted for rules' formation concerning shipping, don't legislate. It's up to countries to endorse those guidelines and adopt them into their legislation in order to become laws. In order for a safety rule to get into force, countries representing a significant amount of shipping (basically with respect of tonnage) must approve and form them into their maritime law.

1.2.2 Fleet distribution

1.2.2.1 Dry cargo

The contribution of those ships in our world is huge since they carry most notably essential materials like coal and ores as well as grains. The extraction regions are far away from the industrials therefore, bulkers are entrusted to bridge this gap.

Table 2 Biggest Dry Bulk Carrier fleets

Country	Number of vessels	DWT	GRT
1. *Japan*	1,791	156,251,060	84,987,256
2. *Greece*	1,878	145,484,209	78,843,115
3. *China*	1,936	124,726,924	69,870,973

1.2.2.2 Tankers

Nowadays oil and its derivatives are major sources of energy and therefore oil carriers make the delivery of them feasible around the world. The shape of those vessels altered through the years in order to enhance efficiency and safety.

Table 3 Largest Tanker fleets

Country	Number of vessels	DWT	GRT
1. *Greece*	1,217	118,621,414	64,347,957
2. *Japan*	938	40,175,492	21,660,620
3. *China*	531	32,954,543	18,094,791

*Data taken in 2014 may have small variations due to dismantling and new building orders

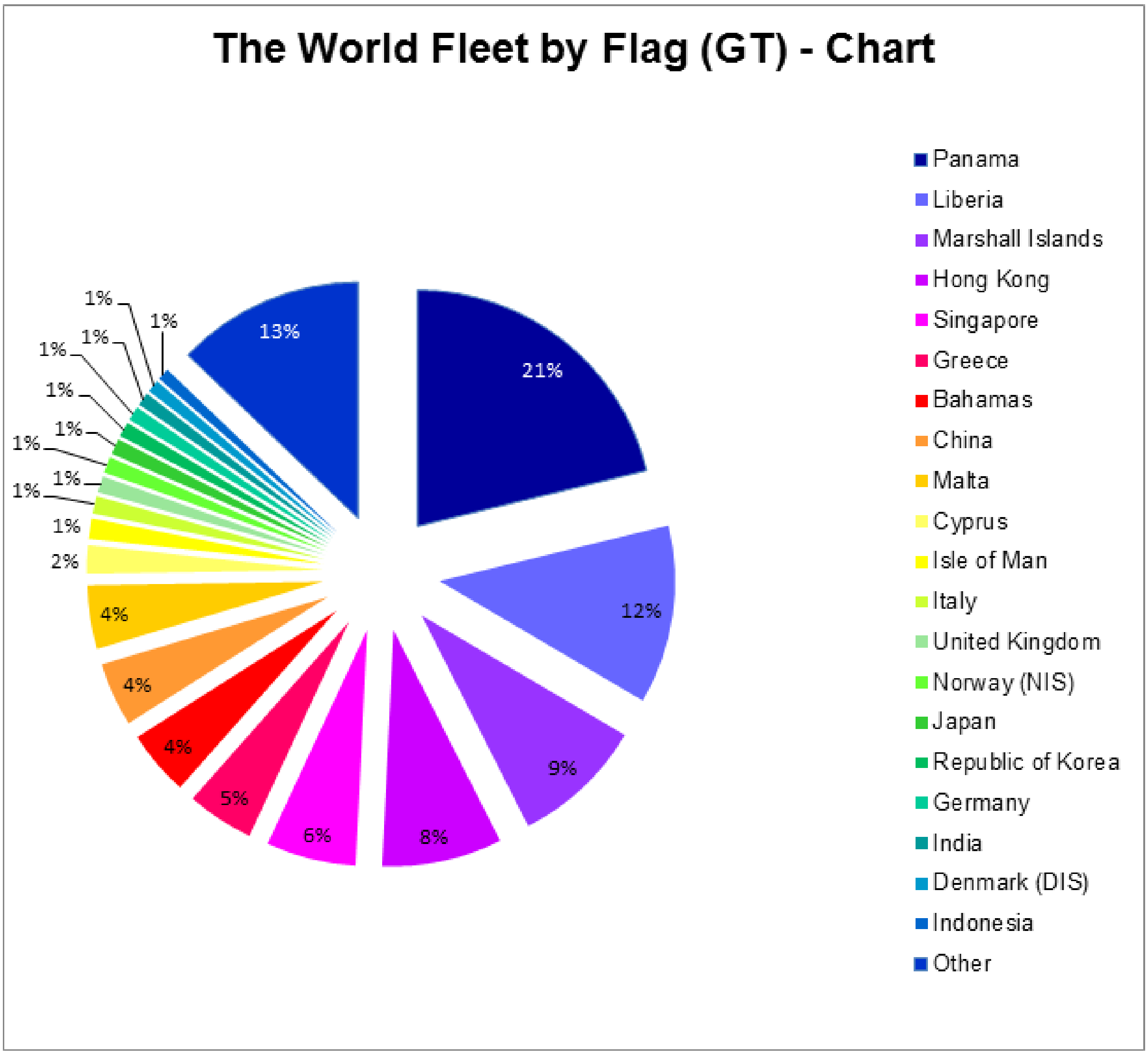
1.2.3 Greek Companies

Greek shipping is mainly a matter of traditional shipping families which operated a small amount of ships. Some of them fight their way through the time and manage to enlarge and expand their fleet. With respect on their DWT capacity the forty largest shipping Greek companies are listed in Table 4.

Table 4 Largest Greek Companies

Largest Greek Shipping Companies			
Company	**Number of vessels**	**DWT**	**Founder(s)**
1. *Angelicousis Group*	137	26.027.862	Antonis Angelicoussis
2. *Cardiff marine Inc.*	115	14.799.629	George Economou
3. *Navios Group*	146	14.392.778	Fragou family
4. *Dynacom tankers*	112	13.900.022	George Procopiou
5. *Tsakos Group*	90	9.275.747	Tsakos
6. *Thenamaris*	89	9.255.932	Mrs Martinos
7. *Star Bulk Carriers*	78	8.633.101	Petros Pappas
8. *Minerva Marine Inc*	65	7.436.949	Andreas J. Martinos
9. *Marmaras Nav.Ltd*	50	7.087.279	D.Diamantidis
10. *Alpha Tankers &Frt.*	44	6.805.760	Chris Canellakis
11. *Diana Shipping*	62	6.575.981	Simeon P. Palios
12. *Eastern Med Mar*	66	6.224.786	Martinos family
13. *Costamare Shipping*	71	5.594.048	K.Constantakopoulos
14. *Golden Union*	46	5.450.696	Michael Veniamis
15. *Capital Maritime*	59	5.368.828	Miltiadis Marinakis
16. *Olympic Shipping &Managt*	27	5.227.308	Aristotle Onassis
17. *Chandris Group*	36	4.555.651	Chandris family
18. *Neda Maritime Agency*	29	4.544.956	Lykiardinopoulos family
19. *New Shipping*	26	4.461.577	A.Polemis
20. *Polembros Shipping*	24	4.391.616	Polemis Family
21. *Enterprises Shipping &Trad*	51	4.219.756	Resti Family
22. *Danaos Shpg*	57	4.026.465	Dimitris Coustas
23. *Centrofin Mngt*	26	3.840.069	D.Prokopiou
24. *Embiricos Group*	26	3.646.938	Empirikos family
25. *Arcadia Shipmngt*	33	3.607.767	K.Angelopoulos
26. *Laskaridis Shpg*	65	3.516.435	Mr Panos Laskaridis
27. *Safe Bulkers*	39	3.497.336	Hajioannou family
28. *Marine Management*	56	3.120.016	G.Klallimanopoulos
29. *Alma Maritime Ltd*	33	2.980.133	Molaris family
30. *Enesel*	18	2.888.283	G.Lemos
31. *Moundreas, N.G.*	26	2.834.565	Moundreas family
32. *Technomar Shipping*	46	2.653.041	Mr. Giouroukos
33. *Fairsky*	20	2.643.870	Fostiropoulos
34. *Samos Steamship*	28	2.586.356	Inglesis family
35. *Transmed Shipping*	20	2.580.403	Chalralampos Mylonas
36. *Nereus Shipping*	17	2.580.274	Lemos family
37. *Eletson Corp.*	48	2.572.352	Karastamati family
38. *GasLog*	27	2.273.175	Mr. Livanos
39. *Lomar Shipping*	67	2.239.124	Logotheti family
40. *KykladesMaritime*	17	2.234.517	Aristeidis Alafouzos

1.2.4 The world's major shipping flags



Source: UNCTAD Review of Maritime Transport, 2014

Figure 1 Flags ranking

Flags represent the legal framework of the country under which the ship operates. The owner's or crew nationality may differ with the flag of the ship. When a country does not adopt Health and safety rules of IMO, as far as the guideline is not an international requirement, a ship sailing with that flag can operate freely anywhere except in the territorial seas of countries that have already adopted this guideline. That phenomenon led to the mostly known as "Flags of convenience" term. In order to reduce the operation cost shipowners can select a foreign flag (flag of convenience) that requires less taxes and chipper sailors. For example, a Greek owned ship with a Liberian flag pay less taxes and does not require hiring Greek crew members and in such way salary costs is also reduced. Often safety measures are not applied with strict ways, comparing to other flags, so the working environment for seafarers become more dangerous. (R.William, 2012)

Flags play a major role in the adoption of IMO conventions. For example if deductions from IMO conventions are adopted from a certain percentage of the maritime (member states of IMO usually with respect of the DWT or gross tonnage) then they become international regulation and all members of IMO must comply. The percentage of each country tonnage is measured only for the ship sailing under their flag. For example if a convention requires a 30% of the world's tonnage in order to enter into force the adoption from Panama and Liberia is enough to enter into force regardless the fact that Panama and Liberian ship-owned ships are few. In this way, even a non-maritime country, with a convenient legislation, can have significant income from shipping and also play a major role in international labor standards.

1.2.5 Classification Societies

The inspection of ships is applied through international surveyors called classification societies. As it is already mentioned, the flag of the ship indicates the legislation framework under which the ship is operating. All ships that prospect under a flag must be registered with an approved classification society. Classification societies on behalf of state flags, classify the ship and issue certificates on the basis of structure design and safety standards. Today there are more than fifty around the world.

LR Lloyd's Register was the first classification society founded back in 1760 representing the United Kingdom's classification Society

BV Founded in 1828 Bureau Veritas is the French classification Society

RINA (Registro Italiano Navale, 1861) well known as the Italian classification society

ABS The American bureau of shipping was established in 1862

DNV-GL is an alliance between Det Norske Veritas (DNV, 1864) and Germanischer Lloyds (GL, 1867)

NKKK Founded in 1899 Nippon Kaigi Kentei Kyokai is the classification society of Japan

RS Russian Maritime Register of Shipping established in 1913

PRS is the Polish Register of Shipping, 1936

CRS is the Croatian register of shipping was created in 1949

CCS China Classification society was founded in 1956

KR the Korean register of shipping created in 1960

IRS is the Indian register of shipping established in 1975

All the above mentioned societies are the largest covering more than 90% of the world's cargo carrying ship tonnage. They formed an alliance and therefore the international association classification societies (IACS) was created in Hamburg, Germany on September 11, 1968.

IACS

The origins of IACS are located way before his establishment back to the age of the international load line convention in 1930. We see that at the very beginning the idea of collaboration between classification societies was formed and thoughts of the uniformity of the standards of strength were expressed in that convention.

The first conference of major societies in 1939 the attendees: ABS, LR, BV, DNV, GL, and NK agreed to further cooperation between them.

1.2.6 Shipbuilding Companies

The advantages of sea transports and the requirements for goods and energy consumption, led to a growing need of ships that can carry cargo all around the world. Some ship building industries started to get bigger and bigger to cope with that excessive need. New technologies and innovations allowed shipbuilding industries to expand through the years and deliver high quality products. Some of the biggest shipbuilding companies are included in Table 5.

Table 5 Shipbuilding Companies

Biggest shipbuilding Companies	
1. *Hyundai Heavy Industries (*1972*)*	located in South Korea
2. *Daewoo Shipbuilding (*1978*)*	located in South Korea
3. *Mitsubishi Heavy Industries (*1934*)*	located in Japan
4. *STX Offshore &Shipbuilding (*1962*)*	located in South Korea
5. *Samsung Heavy Industries (*1974*)*	located in South Korea
6. *Sumitomo Heavy Industries (*1888*)*	located in Japan

The construction line in our days is highly regulated and additionally every ship is inspected during the construction process as well as prior delivery by different groups such as classification society, shipping company's superintendents and yard's inspectors. However, every shipping yard applies his own techniques using his acquired knowledge from previous constructions.

A ship has an estimated life of 25 to 30 years thereat, safe construction techniques must be applied to ensure a successful life cycle of a vessel. Ergonomic design as well as usage of human and eco-friendly materials is a good approach to improve sea transportation.

1.2.7 Largest ports of the world

For the shipping industry, ports are as much essential as ships. Ports make a big contribution to their country's economy, provide job opportunities and attract wealth from all around the world. Due to their important role in the shipping industry, ports were forced to follow the evolution and growth of the ships. Infrastructures for bigger ships and cargo handling facilities were mandatory in order to allow smooth collaboration between sea and shore. Ports were dredged, equipped with state of the art machineries and expand in order to be able to handle some of the biggest moving structures on earth. The catalog with the largest ports of the world based on the cargo handling capacity is listed in Table 6.

Table 6 Ports of the world

Biggest ports of the world	
Name	**Location**
1. *Port of Shanghai*	China
2. *Port of Singapore*	Singapore
3. *Port of Hong Kong*	China
4. *Port of Shenzhen*	China
5. *Port of Busan*	Korea
6. *Port of Ningbo-Zhoushan*	China
7. *Port of Guangzhou*	China
8. *Port of Qingdao*	China
9. *Port of Dubai*	U.A.E
10. *Port of Rotterdam*	Netherlands

During the ancient times merchant ship use to take bigger risks, even compared to warships, sailing in bad weather in order to achieve greater profits. Major ports were among the first players that endorsed safe precautions and restrictions. (BOISSON, 1999) During the last years a growing concern about pollution of the port areas lead to a series of rules for water and air pollution preventions. High activity ports, like Port of Rotterdam, were characterized as emission control areas to reduce local pollution and GHGs. Additional precautions for pollutant discharges were also included on regulations for safe operation of a ship.

PSC Port state control was a result of the ineffectiveness of the flags to comply with surveys and classification duties. They are entrusted with the inspection of ships in port and they have the right to even declare restriction of the ship's departure. In normal conditions they ensure the adequacy of the master and the officers onboard and verifying if the ship fulfills the requirements of the international conventions and the applicable law.

Paris MoU Paris Memorandum of Understanding established *PSC* in 1982, four years after the accident of Amoco Cadiz. Cadiz was an oil tanker that was hit by a storm during its travel from the Gulf of Mexico, to Rotterdam. Crossing the English Channel a wave hit the rudder of the VLCC that issue loss of maneuverability. Despite the efforts to restore the problem and rescue operations by a tug the vessel ran aground then split and sank. Cadiz accident constitutes the largest oil spill history made by a vessel to that date. After the foundation of Paris MOU, the administration decided to inspect at least 25 % of the foreign ships visiting their ports. Several other countries have been signed as well as other regional MoU. Through its operation, it was realized that usually same controls have been performed by neighboring countries on the same vessel in short periods and thus it was decided an international cooperation between harbors to reduce unnecessary delays. Figure 2 illustrates the MoU regions. Us coast guard is an individual party and is not signed as a MoU Port State Control.

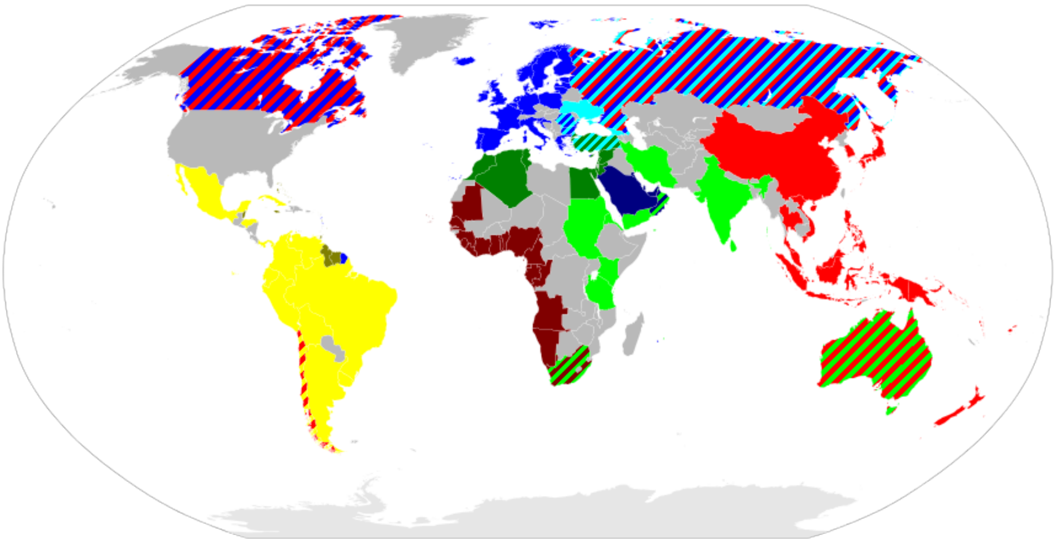


Figure 2 MoU regions

Signatories to the Paris MoU (blue), Tokyo MoU (red), Indian Ocean MoU (green), Mediterranean MoU (dark green), Acuerdo Latino MoU (yellow), Caribbean MoU (olive), Abuja MoU (dark red), Black Sea MoU (cyan) and Riyadh MoU (navy).

2 Important Pathways

Figure 3 Pathways of the world

The people in the maritime industry realized that in order for sea travels to maintain a prosperous and fruitful industry the world's fleet has to be constructed as Safe and efficient as possible. Therefore, bigger ships were built in order achieve low freights and high capacity transportations. As the size of ships increased the problem was out of dough obvious, since ships had to cross narrow pathways, in order to avoid lengthy trips for the same final destination. Those pathways are whether natural like Bosporus and Magellan's Strait or man-made like Suez and Panama Canal. During the years Canals grew alongside with the rising shipping industry and became an important source of income for the local regions. They even applied their own additional safety measurement that every ship that wants to cross their waters should comply. The following pathways play a decisive role for the maritime industry and the global economy.

2.1 The Panama Canal

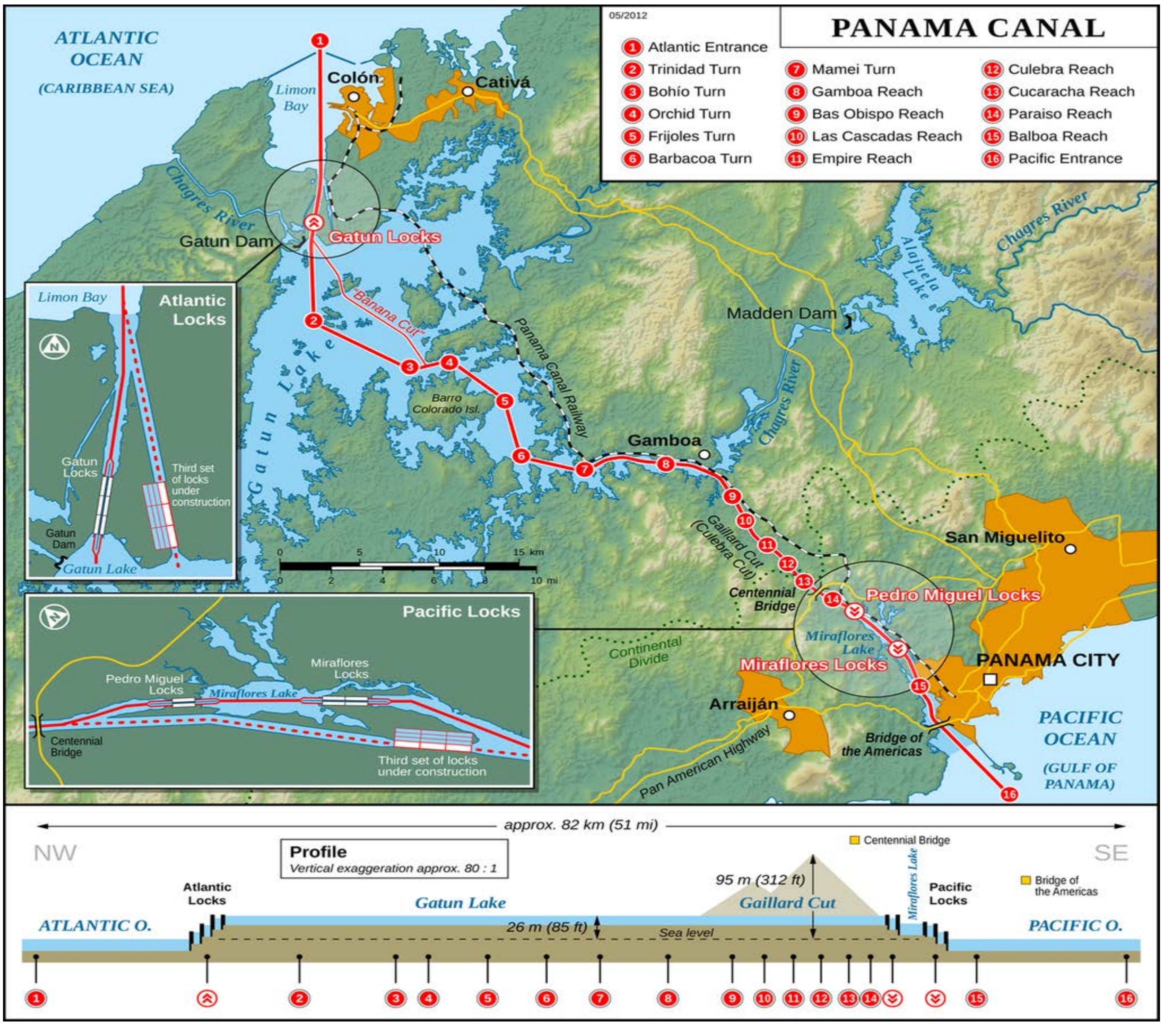


Figure 4 Panama Canal

Panama is an almost 50 mile sea-path that connects the Atlantic and the Pacific Ocean. Using elevating locks, a ship manages to climb up to 26 feet above sea level, sail through the Gatun Lake and then again down to the sea level. The average crossing time is 23 hours The Purpose of getting in such trouble and also pay a significant amount of money for tolls, is that crossing the Panama Canal reduces the journey from Rotterdam to Los Angeles by almost half (42%) and from Shanghai to New York by 14%. It's a fuel and time saving procedure, that also helps vessels to avoid more intensive weather conditions of the southern corner of America. During the construction of the canal, many workers died from tropical deceases like yellow fever, and Malaria. Nowadays, vaccines including these, related to those deceases, are available and also mandatory for seafarers (more information given in chapter 13).

2.2 The Bosphorus Canal

Figure 5 Bosphorus Canal

The Bosphorus Canal is one of the busiest waterways in the world, connecting the Black with the Aegean Sea. It is of major importance path hence all the ships departing from the Black Sea have to cross that canal. Two bridges are crossing the Bosphorus canal and **powerful rapid currents** as well as strong wind forces require maneuvers in order to stay on the right course. Snow, rain and **fog** reduce visibility below 700 meters and in some **sharp turns**, like the Kanlica turn, vessels approaching from the opposite direction are not visible. Schedules of opening an additional water path to decrease the danger due to the great amount of vessels that daily using the canal are still debated from the Turkish Government.

2.3 The Dover Strait

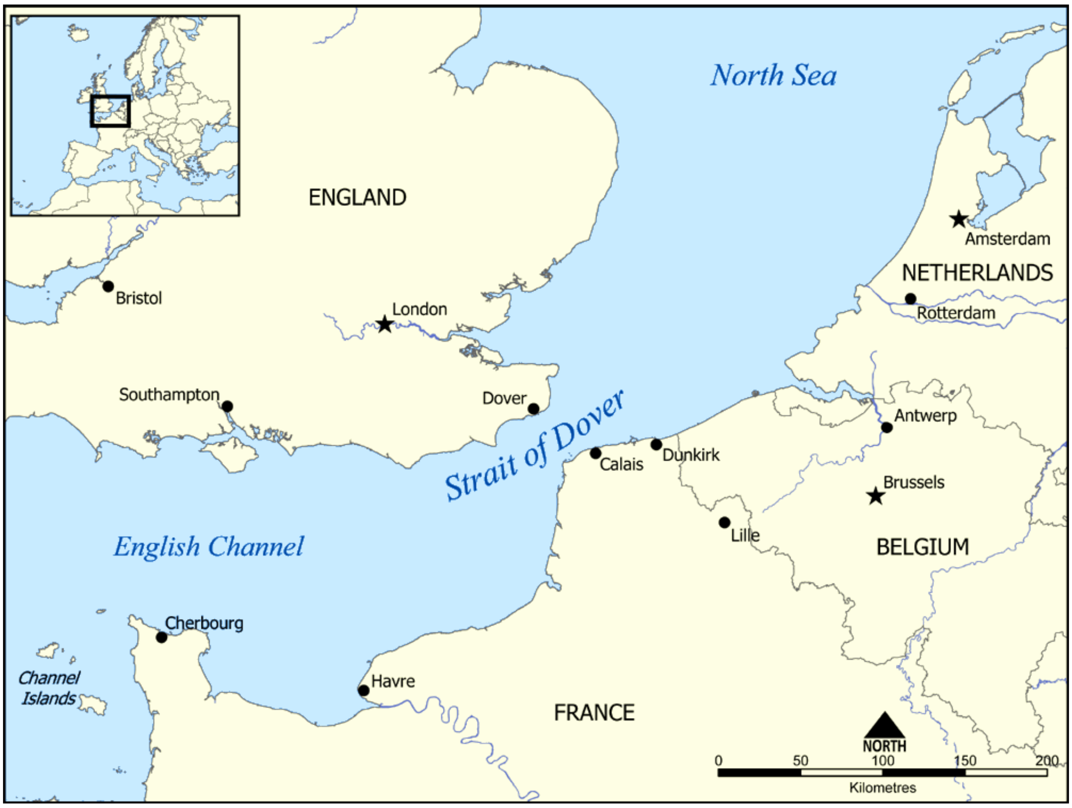


Figure 6 Dover Strait

Numerous of Cargo ships , Tanker, Passenger ship, Fishing vessels as well as smaller crafts sail through the strait of Dover every day. It is ranked among the busiest sea routes in the world and traveling in those waters is as dangerous as it sound. A collision between cargo vessels passing through and smaller passenger ships crossing from Belgium or France to England is likely to happen, especially considering the significant increment of the amount of ships using the English Channel. Despite the introduction of a regimented lane system in the Channel in 1967 the Strait of Dover suffered 26 major tanker accidents between 1951 and 1998. The amount of collisions and grounding are significantly decreased due to IMO's implementation regards to SOLAS Regulations (Chapter V) but collision and disasters, even during the 21th century indicates the safety weaknesses in ship's operation.

The MV Tricolor accident is one of the most famous accidents of our century that led to a triple accident within a fortnight. On Dec 14, 2002 a **collision** between the KARIBA (a fast container ship) and the TRICOLOR (a Norwegian car carrier) end up with the former's bow severally damaged and the latter wrecked with all his cargo (almost 3000 new expensive cars). In addition a cargo ship, followed by another vessel carrying after failing to heed to several French naval warnings collide with the wreck of MV TRICOLOR. An additional oil spill after a tug accidently knocked the safety valve of TRICOLOR added an environmental disaster to the busy Dover strait.

2.4 The Suez Canal

Figure 7 Suez Canal

Included in the most critical sea pathways of the world, the 118 miles Suez Canal connects the Aegean with the Red Sea. The man-made canal was constructed during 1858–1869, under the supervision of Ferdinand De Lesseps. After successfully completing the Suez Canal he failed to repeat his success, attempting the opening of the Panama Canal during the 1880s. The canal is a significantly shorter way, compared to the alternative choice of sailing around the Cape of Good Hope of southern Africa. Like most of the busy sea roads accidents are numerous with the adopting legislation for safety trying to cope with the increment of the amount of goods carried out through the canal. Just like they did with the Panama Canal (Panamax Vessels) shipbuilding focused their efforts to achieve the maximum allowable quantity of cargo that can be carried through the Suez and therefore, the "Suezmax" type vessels are able to transit the canal fully loaded. Political conflicts, led to the closure of the canal multiple times and for long periods. That brought the birth of the supertankers (VLCC), ship big enough to carry huge amounts of oil to cover Europe's energy requirements traveling through the Cape of Good Hope.

2.5 The Strait of Hormuz

Figure 8 Strait of Hormuz

A great amount of oil transported through the Strait of Hormuz, place it among the most strategic points of the world. The Strait of Hormuz connects the Persian Gulf with the Gulf of Oman and the Red sea. During times of international tension, military vessels are always present to ensure that the oil will continue to flow. Between the Sultanate of Oman and the Islamic Republic of Iran, is its narrowest point approximately about 29 miles. Strict navigation rules are applied to avoid collisions. Two different channels are used for inbound and outward bound vessels, with a 2 mile buffer zone in between.

2.6 The Malacca Strait

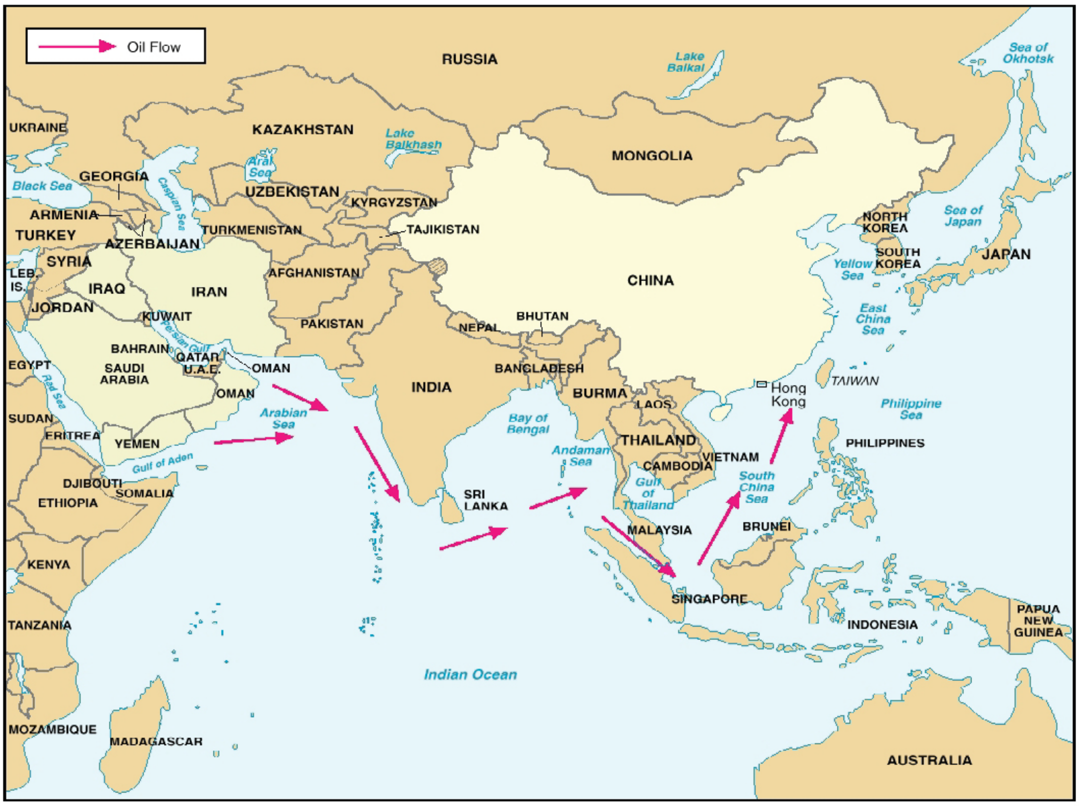


Figure 9 Malacca Strait

The 621 miles Malacca Strait is considered to be the choke point for many of the major economies of Asia (India, China, Japan, Taiwan, and South Korea). All most 100,000 vessels are using the Malacca strait, carrying oil to the manufactory countries and also products to Europe. This pathway saves a lot of miles during the travel to and from the China Sea. The biggest ship that can cross through is referred as Malaccamax. Bigger ship that does not fulfill the requirements (the Strait's minimum depth 25 meters or 82 feet) for using the Malacca strait must use the alternative ways of Lombok Strait, Makassar Strait, Sibutu Passage, or Mindoro Strait instead. One of the biggest problems of the strait is the threat of **piracy and terrorism**. The strategic point of its location is considered an attracting target for a terrorist attack. The geographical morphology of the place with narrow channels, lots of tiny islands and a high number of passing vessels make these waters a perfect place for piracy inflorescence.

2.7 The Welland Canal

Figure 10 Welland Canal (Canada)

The Welland Canal is the link between the Lake of Ontario and the Lake of Erie. It is an essential canal that connects the two lakes bypassing the Niagara Falls. As the canal operates 24 hours per day, variable intensity lighting has been built along the Whole length. The 27 miles long canal has to lift vessels 326 feet (almost 100m) between Lake Ontario (246ft above sea level) to Lake Erie (572ft above sea level) using 8 lifting locks. A series of accidents were reported mainly collisions of vessels with bridges linking the two sides of the canal.

2.8 The Magellan Strait

Figure 11 Magellan Strait (South America)

The Magellan Strait is a natural pathway linking the Atlantic and the Pacific Ocean named by the explorer, Ferdinand Magellan, who successfully navigated the strait back in 1520. Its waters are considered dangerous with **narrow paths**, unpredictable **winds** and currents weaving through numerous small islands. It is a far better choice for many Post-Panamax vessels that cannot use the Panama Canal and want to avoid the violent weather around Cape Horn.

2.9 Pilots

Crossing canals and narrow water paths is undoubtedly the most challenging part during the travel of a merchant ship. The specific features of each channel may challenge even the most experienced captains and thus pilots specialized in navigation of local waters may be required onboard. They usually come onboard prior entering the shallow water area and while the ship is on the move. Using a helicopter or a boat, the embarkation of the pilot can result in an unpleasant situation if the proper attention is not given especially in bad weather. In most of the cases the pilot has an advisory role on the ship and the captain has still the responsibility of the vessel. If he realizes the actions of the pilot may compromise the safety of the vessel, it is in his jurisdiction to release the pilot from his duty and if it is necessary, request another. In cases like Panama the presence of a pilot is compulsory at the pilot has full responsibility during the passing of the canal. (ACP, 2014), (PwC, 2008)

3 Dangers by type of ships and cargoes

3.1 Bulk Carriers

Figure 12 Wan Yang 38183t deadweight

Bulk Carries played an important role for the sea transports during the past years carrying dry cargo such as coal, iron ore, grain, sulphur and scrap metal around the world in the most sufficient way. The great amount of imported iron from China boosted the Bulk Carrier's market and therefore more and more of this type of vessel were ordered to cover the great demand. The result was that when the demand cooled down (approximately in 2008) and the supply of available vessels was so large a huge amount of vessel couldn't find an applicable use and stayed in port or were shipped for demolition. Even newbuilding ordered the previous years went straight to demolition yards due to the saturated shipping market of Bulk Carriers. They are still used in many travels, but their economy is suffocated from the oversupply. Types of different size Bulk Carriers are listed in Table 7.

Table 7 Bulk Carriers Categories

BULK CARRIERS	
Name	**DWT**
Handysize	20,000 ÷ 40,000 DWT
Handymax	40,000 ÷ 50,000 DWT
Supramax	50,000 ÷ 60,000 DWT
Panamax (B ≤32.24 m) *Kamsarmax (enter port of Kamsar, Equatorial Guinea)**	60,000 ÷ 80,000 DWT ≈82,000 DWT
Post Panamax ("baby capers")	<125,000 DWT
Capesize *Dunkirkmax (enter the French port's eastern harbor lock at Dunkirk)*** *Newastlemax (enter port of Newcastle, Australia)**** *Setouchmax (navigate the Setouch Sea, Japan)*****	125,000 ÷ 200,000 DWT ≈175,000 DWT ≈185,000 DWT ≈203,000 DWT
Very Large Ore Carriers (VLOC)	>220,000 DWT

*Kamsarmax vessels fulfill the Panama requirements, thus they barely fit in the locks, but their length is above the average Panama-ship (LOA ≈ 229). Also, they are the largest ships that can enter the Port of Guinea (the biggest port of bauxite deposits). Most Kamsarmax vessels carry a wide variety of cargoes such as bauxite, coal, cement, iron ore, steel pellets, grain, soybeans, and fertilizers.

** max LOA = 289m and max. B = 45 m
*** max Beam = 47m
**** low design draught of 16.10m and max. LOA = 299.9m
Some of combined types Bulk Carriers (ore/bulk/oil) were also developed. The OBO ships are able to handle both liquid and dry cargo. Additionally Conbulkers (container/bulk) can load both containerized cargo and bulk cargo, generally provided with wide hatches and lifting equipment. In periods of high demand some of the VLCC vessels were converted to VLOC. Bulk Carriers are recognized for their characteristic hatch covers and some of them rarely carry their own cargo handling equipment (geared bulk carriers).

Figure 13 CSL THAMES Self-discharging

Figure 14 C.S. STAR (geared Bulk Carrier)

Bulk carriers are involved in many accidents, most notably due to **structural failure**. “Bulkers” are considered to be “the great workhorses of the shipping world” carrying a variety of dry cargo from heavy iron ore and scrap metal to lighter substances as grains. Structural failures have been occurred from heavy loads that caused local buckling and damage from unloading equipment. **Corrosion** is another issue, that threats ships, especially when corrosive substances like sulphur and heavy cargo (i.e. ore) were alternately transported as usually happens with a bulk carrier. **Cargo shift** in the cargo hold, which may occur due to bad weather, may drive to unfavorable list that may compromise the integrity of the ship.

The following accident may reveal another threat related with this type of ship. On January 1, 2015 the “BULK JUPITER” was capsized while carrying 46.400 metric tons of bauxite. The accident appears to happen due to the **liquefaction of cargo** and eventually only one from the 19 crew members survived. According to the IMSBC bauxite is a Cargo C, which means that it belongs to cargoes that are neither liable to liquefy nor possess chemical hazards. However, in some cases, especially with high percentages of powder within the cargo bauxite has an almost similar exhibit of liquefaction as nickel ore, which is included in Cargo “A” type. Table 8 illustrates the division into the three categories and some cargo sorting. (Lloyds, 2013)

Table 8 Cargo sorting according to IMSB code

Category	**Basic characteristics**	**Cargo**
Cargo A	Cargoes which may liquefy	Nickel Ore, Coal
Cargo B	Cargoes with chemical hazards	Metal sulphide concentrates, organic materials, ammonium nitrate-based fertilizers, wood product, DRI
Cargo C	Cargoes which are neither liable to liquefy nor possess chemical hazards	Iron ore and high density cargoes, Sand and fine particle materials, Cement

*Coal can be classed as both A and B cargo

3.2 Refrigerated Cargo Ships/ Reefer Vessel

Figure 15 Reefer vessel

Reefers are ships with the ability to transport cargo that needs low temperature to remain fresh. They were built to carry mainly fruits, meat, seafood, vegetables, etc. Perhaps the most known, are the banana carriers that transport goods between the Caribbean and Europe. Statistically the greater use of those vessels is during the months of February and March. Like any transaction that it is governed by seasonality, they have high and low activity period. Unsteady demand and refrigeration facility developments in other type of vessels, such as the ability to carry refrigerated containers in holds or on deck pose a question mark on their future sustainability. The most common threats concerning those vessels are **collision** and **asphyxia**. Reefers are designed to carry cargo that is sensitive to heat. Therefore, thick hulls to reduce resistance and adequate horsepower engines allow reefer vessels to achieve higher speeds compared to many other merchant vessels. The cargo (basically fruits) despite the fact that looks harmless, hides threats. Cargo is carried out under controlled atmosphere conditions to manipulate ripening of fruits and delay fungal growth. Those conditions require low level oxygen and for that reason, entering non proper ventilated areas can cause loss of consciousness, permanent brain damages or even death from **suffocation**. Besides this technical environment also CO_2 emissions produced by fruits can rise up to a dangerous level. In the atmosphere CO_2 constitutes about 0.04%, but in poorly ventilated rooms full of fruits, CO_2 levels can exceed a 5% (regularly recorded in bananas holds) (Kohli, 2000)

Reefer are not in the top list of for engaging in accidents however the following accident of "Nagato Reefer" will reveal some dangers that can occur also in other types of ships.

On 9 April 2014 a lifeboat of the vessel fell from its davit and as a result one crew member injured and the lifeboat was damaged. The incident took place during an abandon ship drill after a Port State Control request due to many deficiencies identified by the port authorities of Southampton, UK. A wrong reset of the lifeboat that was previously lunched led to the accidently slide of the lifeboat. **Low competency of the crew** members, **poor maintenance** and altered records of SOLAS **safety drills** and other statutory requirements had been identified as key elements that compromised the safety levels of the ship.

3.3 General Cargo Vessels

Figure 16 General Cargo ship

Until the era of the specialized cargo vessels, sea transportations took place through general or dry cargo ships. They typically have their own gear, for cargo handling, in order to be independent from the port of visit. Since the appearance of Bulk Carriers and Tankers those ships lost their prosperity. In addition, containers brought another hit to the dry cargo vessels since the time to load and unload a same amount of goods was significantly decreased. Dry and general cargo vessels still operate in many places around the world, but their size is much smaller (rarely above 50,000 Gross tons) than the competitor's specialized ships.

On 6 July 2012, an accident on "JUNIPER PIA" general cargo ship resulted the fatality of a 21 year old crew member. The casualty occurred during the night prior berthing into the Port of Fukuyama. The ship was requested by the shipping agent to remove the hatch covers (if possible) prior berthing in order to allow performance of cargo handling operations faster after berth. The young man was found dead due to fracture of the skull and traumatic cerebral hemorrhage after **falling from height** into the cargo hold. The removal of the hatch cover took about an hour and the accident could be avoided if the procedure took place after berthing. An additional cause of the accident was **insufficient lightening**. Lights in the cargo hold could be left open in order to not interfere with the navigation lights and visibility. After the accident safety barriers were placed and it was also decided that hatch cover will always be removed after berthing. (JTSB, 2013)

3.4 Container Ships

Figure 17 Mærsk Mc-Kinney Møller

The concept of this vessel is based on the idea of door to door delivery. A variety of cargo can be carried out through a single voyage and then quickly be unloaded and shipped through railways or trucks to their final destination. The standardization of the size of the carrying boxes (FEU/TEU) defined the vessel's dimensions (length, breadth, depth) as well as the cargo handling equipment that made the loading and unloading of these vessels even faster. Large open decks allow the carriage of containers on the open deck. Rails and lashing is used to prevent cargo from falling into the sea. Containers with dangerous cargo are marked and located at the ship's bow, away from the vessel's superstructure and accommodation.

Since their first appearance Container Ships grew in sizes reaching today's capacity of over 18000 TEUs. The primary idea was fast deliveries so container ship's hulls are still thick to reduce resistance. The amount of units to be carried above deck ensures that an adequate total number is transferred during the travel despite the lack of space in holds. Although the transportation benefits, numerous of **containers fall into the sea** every year, causing a serious threat to crossing vessels or environmental health in case of harmful content.

Rise of fuel cost and regulations lead to lower speed and make an approach based on efficiency. With the use of certain innovations such as refrigerated boxes the container ship's fleet took a large piece of other special purpose vessels such as reefers offering a new option in sea transportations.

Container ships are engaged in many accidents concerning **collisions**, container loses after **lashing failure**, **fire** carrying flammable containerized substances, etc. The following accident of the "Alva Star" container ship may reveal some additional threats related to ship transportations. On the 3rd of October 2002 the 235.7m container ship loaded with 41,570 dwt cargo grounded on the east side of Zakynthos during its scheduled course from Haifa (Israel) to Kepec (Croatia). The incident occurred due to a **navigational error** during the night with full speed of 22 knots and as a result, the bow as long as 25 meters of the forward section was stuck into rocks. After the engagement of a US salvage, firm the ship was finally free after unsuccessful previous attempts.

The navigation systems nowadays are more accurate and reliable than ever before and as a result the mistake of taking this accuracy for granted, reducing the safety margins and not performing checks, is usually detected onboard. Another dangerous issue for this type of ship is the **uncertainty of the content** of a container. Insufficient cargo securing can result, undesirable list or damage of the cargo. Carriage of camouflaged weapons, drugs or hidden stowaways may lead to unpleasant results.

3.5 Livestock Carriers

Figure 18 Al Kuwait (ex Al Shuwaikh) capacity of 125.600 sheep

The carriage of live animals is achieved with livestock carrier. They mainly carry sheep and cattle. Due to their usual cargo, experienced and specialized operators are required. Those ships are dangerous due to the possibility of animal contagious deceases and potential injury from animals. Also in case of a malfunction a huge number of animals can be injured or die. Those vessels are equipped with ramps and automatic food and water supply mechanisms. Good ventilation circuit is essential in order to successfully carry out live animals thousands of miles from their origin place.

Danny F II was a livestock carrier which capsized and sank on 17 December 2009. The accident took place eleven nautical miles (20 km) from Tripoli (Lebanon) due to **bad weather** while performing a travel from Uruguay to Syria. Up to 10,224 sheep and 17,932 head of cattle among with 30 people when down with the ship while 47 were saved during rescue operations under poor conditions. *Danny F II* was previously a car carrier named *Don Carlos* built in 1975. It was modified as a livestock transporter in 1994 and started to operate in 1995 under the Liberian flag. In 2005, it had been detained at Adelaide (Australian port) for poor bulkhead condition, problem in navigation and communication equipment and **defective watertight doors.**

3.6 LNG Carriers

Figure 19 AL MAFYAR Tanker (LNG) L=345.3m DWT=130441tons

Those are ships of the twentieth century since LNG became an alternative choice of preferred fuel. Countries like Japan uses LNG to power their industrial needs. LNG finds more and more ways as the alternative fuel compare to oil based on the fact that it is considered as a greener solution than its rival. Liquefied Natural Gas is not liquid at ambient temperature. In order to a considerable amount to be carried LNG as gas is transformed to liquid through the liquefaction procedure. In order to maintain LNG cargo as a liquid, a minus 160°C temperature is required. It is quite easy to understand that carrying a flammable cargo in a rather unstable condition is very dangerous and requires a lot of safety precautions as well as careful handling. Regardless the high risk in LNG transportations LNG Carriers have the best safety record of all maritime vessels. LNG carriers are considered to be tankers, but due to their special design and their steady growth in today's global market they are presented separately.

On December 3, 2012 "LNG ARIES" with 32 crew members and a load of 125,469 m^3 liquefied natural gas, **lost control** prior berthing in Keihin Port (Japan). The incident ended with no casualties and the ship with the escort of four tug boats successfully finished his travel. The cause of the accident was a failure on the electrical systems of the ship that caused a **blackout**. Even if the incident ended with no further complications the danger behind such situations is of major importance. If there is a rupture on a fuel tank, LNG will boil rapidly and escape to the atmosphere. If there is no ignition source a cloud of a flammable mixture can travel in a considerable distance and ignite from an external source when conditions are favorable. If such scenario is performed in a harbor populated areas may be in great danger.

3.7 Tugs

Figure 20 Tug pushing a log raft near Vancouver

Tugs are a very useful type of vessel and their size and engine capacity varies, depending on their tasks. They are engaged in towing vessels into ports, firefighting, salvage operations anchor handling/positioning, etc. These vessels have an engine capacity of 500kW (620HP) for small harbor tugs up to 20,000kW (27,200HP) for big deep sea operators. Their power/tonnage ratio is at a considerable high level compared to normal cargo ship.

Table 9 Tugs' power ratio

Ship type	Power/tonnage ratio (in kW/GRT)
Normal cargo ship	0.35 to 1.20
Big tugs	2.20 to 4.50
Small tugs	4.0 to 9.5

Tugs are very flexible and can perform easily 360° turns. Propulsion systems like azimuth pods allow high maneuverability. For safety reasons tugs are equipped with two of each critical part for redundancy. With their special design hull, they can push efficiently ships that may be ten times their size. Escorting vessels in narrow pathways and helping giant ships to move in and out of ports is in the jurisdiction of tug vessels.

Although tugs are usually performing rescue operations, they can be possibly involved to a dangerous situation like **capsizing**. The powers that are present during towing are enormous and any mistake can result to a fatal incident that will happen instantly. For example, when a towing line is in tension, an external force is applied upon the tug and if the power exceeds the righting lever the tug will capsize. (WEIS, 2013)

Diver Master (a tug vessel), is one of the cases that went terribly wrong during operations. On August 4 2014 Diver Master, along with tug Svitzer Helios (both tugs) were assigned to help the "Kruzenshtern", a very large tall boat to get out of the harbor. The two tugs were attached to the vessel with hawsers but while "Svitzer Helios" properly detached, the "Diver Master's" **release mechanism stuck** resulting the flooding of the tug that later sank

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3.8 Car Carriers

Figure 21 Höegh Target, largest PCTC, beam 36.5m, LO 199.9m

Car carriers are used by car manufacturers in order to carry their products across the world. They have characteristic rectangular shape and they carry millions of cars between different continents every year. They are designed to accommodate all types of cars from passenger cars to construction machinery. They have multilayered decks, in order to stock as much cars as possible. Their vulnerable spot is the vast, unsecured, with no watertight bulkheads, car deck. The **lack of transverse subdivision** and the free surface effect can destabilize the ship in no time in case of water in the cargo deck.

The example of "Hoegh Osaka" accident, which took place on 3 January 2015, will reveal some threats concerning this type of ship. The car carrier having already some vehicles on his deck was loaded at Southampton in order to sail from England to Bremerhaven (Germany). The "Hoegh Osaka" after making a port turn with a speed of 12 knots developed a severe list in "Solent Stait". According to the accident report from Marine Accident Investigation Branch (MAID) the ship was deliberately grounded by the pilot and subsequently settle to a heel of 52°. **Vehicles were shifted** in the cargo holds, but research point out that it wasn't the cargo shift that caused the list. The problem was probably related to the **metacentric height** (GM) of the vessel since investigation found that no stability calculations have been made. This issue is found in many cases, most notably when a ship is performing stationary journeys. The weight of cargo was also underestimated by 265 tonnes due to miss calculations onboard. Additionally, some **straps** used from securing the cargo were found inadequate and problems with ballast indicators, that haven't been fixed for a long period, required manual readings of ballast water content.

3.9 Passenger Vessels

Figure 22 Carnival Freedom Cruise Ship, Capacity 2980 Guests, Onboard 1150 Crew members

Passenger ships have as a main purpose the transportation of people. There are some hybrids like Ro-Ro-Passenger ships but cargo vessels that include accommodations for limited number of passengers are not included in this category. They can be divided by the type of trip they perform. There are small ferries for short distances but also great ocean liners crossing for instance the Atlantic Ocean. With the developments in air transportation, many of those large cross-Atlantic vessels turned into cruise ships and therefore the once small cruise market started to expand. The cruiser ship usually performs a round trip with lots of stops along coastlines or among various islands. The purpose of the travel is pleasure and vacation on sea thus those vessels are fully equipped with all considerable recreation facilities. Safety regulations are extremely strict due to the huge amount of people traveling in a single voyage.

People are considered to be among the dangerous cargo because they can react unpredictably and cause damage to the ship, other passengers as well as their self. Accidents on passenger ships and evacuation processes are roughly studied due to the large amount of people they are carrying and the impact that passenger's ship accidents have on people's mentality.

Taking a closer look at the accident of the Korean ferry, "SEWOL" someone may find many obvious and hidden dangers of this type of vessel. One of the most tragic losses of the 20th century occurred on April 16, 2014, were 304 passengers (mostly young students) were perished after the capsizing of the ship at the coast of South Korea. According to reports, the 18 year old ship committed a series of violations that contribute to this fatal accident.

Illegal modifications have been made upon the vessel that added tons to its weight. Furthermore the day of the incident the ship was **overloaded,** carrying two times the legal weight limit. Additionally, the ship carried **inadequate ballast** in order to load more cargo. In combination with a sudden turn in dangerous channel, from a crew member with **no experience of steering** through the "Maenggol channel" (Yellow Sea), the ship took an irreversible list and capsized. The instability of the ship was also fueled by **unsecured cargo,** but the high death toll of the accident has roughly included accusations for **failure of evacuation.** Approximately 172 from the total 476 people onboard were saved and half of them by fishing boats and other vessels in the vicinity.

3.10 Heavy-lift Carriers

Figure 23 Blue Marlin carrying a drilling unit

Heavy-lift carries are special-purpose vessels dedicated to load very massive structures on their deck. They have been use from the oil industry in order to transport drilling units to their drilling location. Self deploying drilling units have been built but using heavy-lift carriers, transportation can be up to four times faster. After the end of the operations of an extraction unit, pipes and holes are sealed and it may be needed for the oil ring to be transferred in shore or in a new drilling place. Heavy-lifters have the ability to submerge below a floating unit by ballasting their tanks and then emerge by de-ballasting, lifting the cargo on their solid deck. Some heavy-lift carries are also used to carry smaller vessels, submarines, barges or heavy equipment.

On 9 December 2003, a heavy-lift carrier "MV Stellamare" capsized and sank in the icy river of Hudson River (Port of Albany, N.Y). The capsize performed within a minute and three crew members died when water flooded the cargo hold of their working area. During the accident, a 340 tons stator was loaded on the vessel. A sudden list of the vessel during the

loading operation had as result the stator to drop and sink to the river's bottom acting like an anchor. Cargo inside the vessel also shifted, but the main causes of the accident could not clearly be defined by the U.S coast guard.

3.11 Tankers

Figure 24 Company Tokyo Mitsui OSK Lines (MOL) (VLCC tanker)

Tankers were built to carry liquid products. Crude oil is the most usual cargo but also refined products such as gasoline, aviation fuel, petrol, kerosene and paraffin are carried as well. Tankers went through lots of modifications during their first appearance in order to achieve high efficiency and safety. Back at the time tanker's capacity was measured through barrels, because this was the way that cargo was stored into the vessels, in order to be transported. That was the time when still wooden ships were dominating the world. Innovations in technology and design allowed cargo, to be carried out using the ship's hull instead of barrels. Greater amounts of cargo were carried faster and in longer distances. People engaged in tankers operation had to face new serious challenges regard to cargo handling procedures(charge/discharge), environmental pollution(spills), and ship's design(free surface effects, sloshing, etc.) . After numerous accidents of tanker ships through the years, tankers took their final shape. Different cargo requires customized safety procedures and equipment. Despite been high regulated, tankers have been involved in a great amount of environmental disasters and new safety measurements are still appearing until today. For small vessels up to "sea giants," tankers are built in many sizes.

Table 10 Tanker's division per size

TANKERS	
NAME	**DWT**
Seawaymax *Handysize* *Handymax*	10,000 - 60,000 DWT 20,000 - 40,000 DWT 40,000 - 50,000 DWT
Panamax	60,000 - 80,000 DWT
Aframax	80,000-120,000 DWT
Suezmax	120,000-180,000 DWT
Very Large Crude Carrier (VLCC)	200,000-320,000 DWT
Ultra Large Crude Carrier (ULCC)	>320,000 DWT

Regardless of their negative points, more than half of the total amount of needed oil is transported through tankers and 99% is delivered safely making tankers the flywheel of our century. Hazards and accidents are highly related with the transported cargo. Therefore tankers are subject to further subdivision. In that manner more specific attention and confrontation can be given with regards on safety matters.

3.11.1 Chemical tankers

Due to their design chemical vessel can carry hundreds of different types of cargo, from petroleum products, inorganic acids and fish oil to specialty chemicals. The complexity of the vessel and the fact that most of the transporting liquids are considered extremely hazardous indicates that careful handing is required.

There are merely 3 *types of chemical tankers:*

- **Type 1**

It is built with the strictest rules in order to be able to handle the most dangerous cargoes. This vessel has not any wing tank and the tanks are located around the centerline. It's the smallest of the three categories and it is constructed with high double bottoms near the 1/6 of its depth. The main construction material is INOX in order to avoid chemical corrosion. Void spaces and cofferdams between tanks, block contact of different chemicals in case of a leakage. Every tank should not exceed the volume of $1500m^3$, has its own manifold and for the washing process, special dissolvers are used instead of sea water. Those types of vessel are designed to cope with the most extreme conditions and avoid a leak, even after collision or grounding.

- **Type 2**

This type of ship is larger than the previous one and contains bigger cargo tanks (however, tanks should not exceed 3000 m^3) which are also located in the center of the ship (no wing tanks). Similar to type 1 the type 2 vessel possess individual valves for each tank but the latter are separated with just bulkheads instead of cofferdams.

- **Type 3**

Type 3 vessels are designed to carry the least hazardous chemicals according to the IBM code and have no strict structural limits like the previous ones.

According to MARPOL Annex II every chemical tanker is required to have a Certificate of Fitness (CoF) indicating that it is fitted to carry certain products.

3.11.2 Liquefied Gas Carriers

Gas shipping began approximately in 1920. The first cargo was propane and butane carried in liquid form in high pressure and ambient temperature. Developments in metallurgy and refrigeration systems allowed, in 1959 liquefied gases, to be carried in lower pressure at low temperatures. Furthermore the appearance of fully refrigerated ships permitted the cargo carriage in atmospheric pressure.

A liquefied gas has been defined in terms of its vapor pressure as a substance whose vapor pressure at 37.8° C is equal to or greater than 2.8 bar absolute (IMO definition).

Liquefied gas carriers can be divided into six categories according to IMO based on the carried product. (CCNR & OCIMF, 2010)

- LNG

Figure 25 LNG carrier tank

Liquefied natural gas is a product drained from the earth and it is a mixture of methane, propane, ethane, butane. LNG in mainly transport through pipelines and only a small portion is carried by LNG vessels. LNG carriers have a big and expensive cooling plant in order to keep the cargo at the appropriate temperature and their engines can burn their own cargo as fuel.

- NGL

"Natural gas liquid" or "wet gas". Those gases exist in raw oil and can be separate during the refining process. NGL is consisted by Ethane, LPG, Pentane and heavier fractions of the crude oil

- LPG

Gases referred as LPG are butane, propane or mixture of these. They are taken from refining procedures of raw oil or separation of LNG.

- Fully pressurized vessel

This vessel's pressure is to be kept in high values of 18bar approximately, temperature around 45°C (in case of propane C_3H_8) and has spherical tanks giving the ship a characteristic shape. Cylindrical tanks may be also used. The usual size of the dams is $4000m^3$ carrying mostly LPG and ammonia.

- Semi-refrigerated vessel

With the development of metals, able to cope with low temperatures semi pressurized vessel were constructed. The operation conditions are -10°C (degrees Celsius), 5-7bar and the capacity of a tank is around $7{,}500m^3$. An isolation system is required in order to maintain those low temperatures. Tanks may vary in shape been cylindrical, spherical or bi-lode. The reduction of pressure allows the application of thicker and lighter tanks.

- Semi-pressurized/fully refrigerated ships

This type of vessel is quite flexible due to the fact that can handle cargo (load-discharge) from both pressurized and refrigerated storage facilities. It can reach the size of $30000m^3$ and can carry a variety of gases. Special alloyed steels or aluminum allows temperatures 104°C below zero (ethylene ships).

- Fully refrigerated

Prismatic filmy tanks in that vessel can keep the cargo at very low temperature 48÷104 degrees Celsius below zero at atmospheric pressure. Fully refrigerated ships range in size from 10,000 to 100,000 m^3. The operation of those vessels is more limited than the previous category due to the special requirements from the terminal for the handling of the cargo. In some cases, heaters and boosters can be used to allow discharge also into pressurized storage facilities. To prevent cold cargo to get in touch with the ship's hull in case of a leakage of the piping system planks or plywood is used.

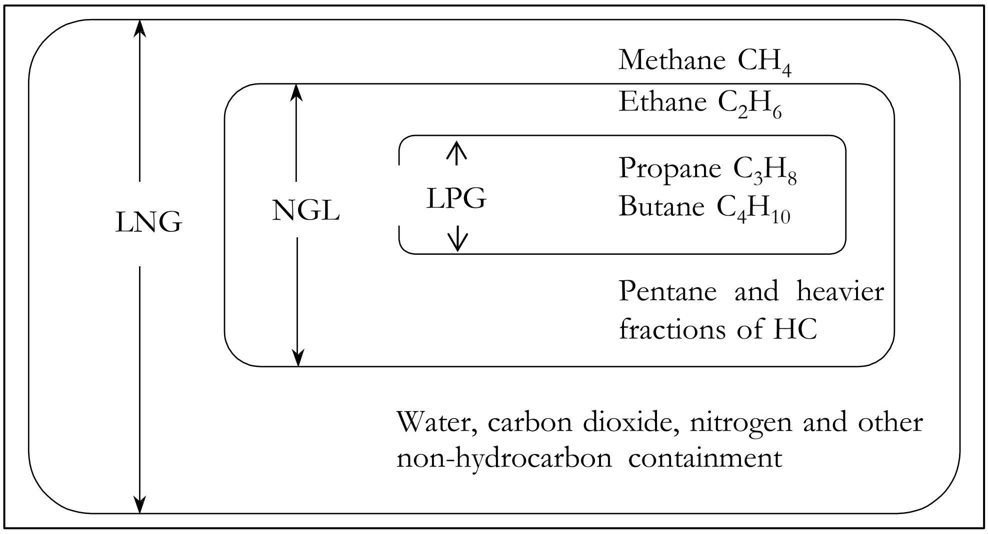


Figure 26 LNG division

- LEG - Liquefied Ethylene Gas

This gas is not a natural product, and is extremely combustible with a flammable limit from 2.5% to 34% by volume mixed with air. It is carried by gas carriers characterized as LPG/LEG carriers.

- NH3 - Ammonia Carriers

Ammonia is characterized as poison gas and has a TLV of 25ppm. It is transported with atmospheric pressure gas carriers or semi-pressurized gas carriers and has a boiling point of -33°C, at ambient temperature. Ammonia is not highly flammable, but tanks that contain ammonia may explode when exposed to high heat. The definition for a tanker who carries ammonia is LPG/NH carrier.

- Cl_2 - Chlorine Carriers

The special about this cargo is the fact that it is not flammable. Although chlorine is very toxic and therefore, it is transported in small portions. The vessel that carries chlorine must be type 1G that means the cargo tank must be at the least lie B/5 "Breadth/5" up to 11.5 meter from the ships side.

All the liquefied gases (except chlorine) have density less than 1 gram per cubic centimeter, so in case of a spillage the liquid will float until his total evaporation. (IMO, "Seafarers' Training, Certification and Watchkeeping Code" (STCW Code), 2005 edition)

4 Dangers related to flammable liquids and toxics

The dangers concerning ship occupation are numerous since ships operate in an unstable and dangerous sea environment. However, hazards through everyday life on a ship are highly related with the transported cargo and the occupations onboard. The particular aspects of each cargo require special attention and careful handling. Knowing the key features of each dangerous procedure is in favor of Health and Safety.

4.1 Tanks' pressure

Liquids that fill tanks have the ability to expand when they absorb heat. This phenomenon is more intent when the temperature of the liquid reaches the point of vaporization. Gases produced from the vaporization need multiple amount of space from their previous liquid form and therefore, exert additional pressure on the side of a tank. For example a liquid such as water if heated at 100°C in ambient conditions turn into gas and expands by approximately 1700 times. If it is contained in a close tank, the pressure rises because the lower density gas needs more space.

Gases can divide to **volatile** and **non-volatile.**

We can characterize a liquid as *volatile* when under the threshold temperature of 60°C has the tendency to turn into gas. If that procedure occurs over the mentioned temperature, the liquid is *non-volatile.*

A more scientific approach can be taken with respect to the **Reid Vapor Pressure**. If R.V.P. is measured less than 0.1 psi at 37.8 °C (100°F), the substance is "non-volatile". In the opposite if RVP is greater than 0.1psi we deal with a volatile liquid. (ASTM, 1999)

A tank full of liquid, can possibly submit to cracks or total failure. For that reason, different tactics and protective equipment are used to minimize the threat.

All tanks of oil or chemical tanker are equipped with **relief valves**. The *P.V.V* (pressure vacuum valve) is the first level of safety in order to cope with unfavorable pressure in a storage chamber. If the pressure is too low or too high regarding the safety limits, the P.V.V opens automatically and reliefs the lack or the surplus of pressure. More precisely the typical settings for P.V.Vs are 1400mmWG and -350mmWG. Although the minimum structural limits of tanks are: +2.550mmWG and -700mmWG according to SOLAS.

A second barrier called *P/V breaker* minimize the threat due to a malfunction of a P.V.V. The settings of a P/V breaker for overpressure and underpressure are 1800mmWG and -500mmWG respectively. (IMO, "Technical Information On Systems And Operation To Assist Development Of Voc Management Plans", 2009)

Correct maximum filling of a tank is such a quantity when a portion of the cargo is evaporated and activates the relief valves 2 percent of space will remain.

Vapor inside holds is created mainly with two ways: A portion of vapor is generated during the COW and also during the loading procedure. Turbulence in the fluid and pressure differentials within the pipe lines leads to a significant proportion of vapor. This amount of vaporized hydrocarbons can be measured by many sensors within the tank and can be released into the atmosphere through the third safety system called _mast riser valve_ during the loading. The exit location of the mast riser is at least six meters above deck and allows a great amount vapor discharge, equal to the loading amount of cargo.

After the loading is completed the mast riser remains closed and a positive pressure in the tanks ensures that oxygen from the atmosphere won't come in.

During the travel of the ship, gases regularly are released to the atmosphere automatically or manually. Temperature is undoubtedly a major factor to the condition of the cargo and therefore, it is measured and regulated with various systems. The temperature of the environment and especially sea temperature has an impact to the temperature of the hull and progressively to the cargo holds. Double hull construction of oil vessel reduces the thermo flow between cargo hold and sea due to the *"Thermos Effect"*. In that case heat exchange isolation is provided due to the void spaces hence, cargo remains near the loading temperature. During the discharge mast riser remains close and inert gas replaces the free space.

Crude oil is the most common unsafe cargo to be transported through seas since it is still a major source of energy on our planet. Its fractions can be obtained through the distillation process which is described in the simplified shape of Figure 27.

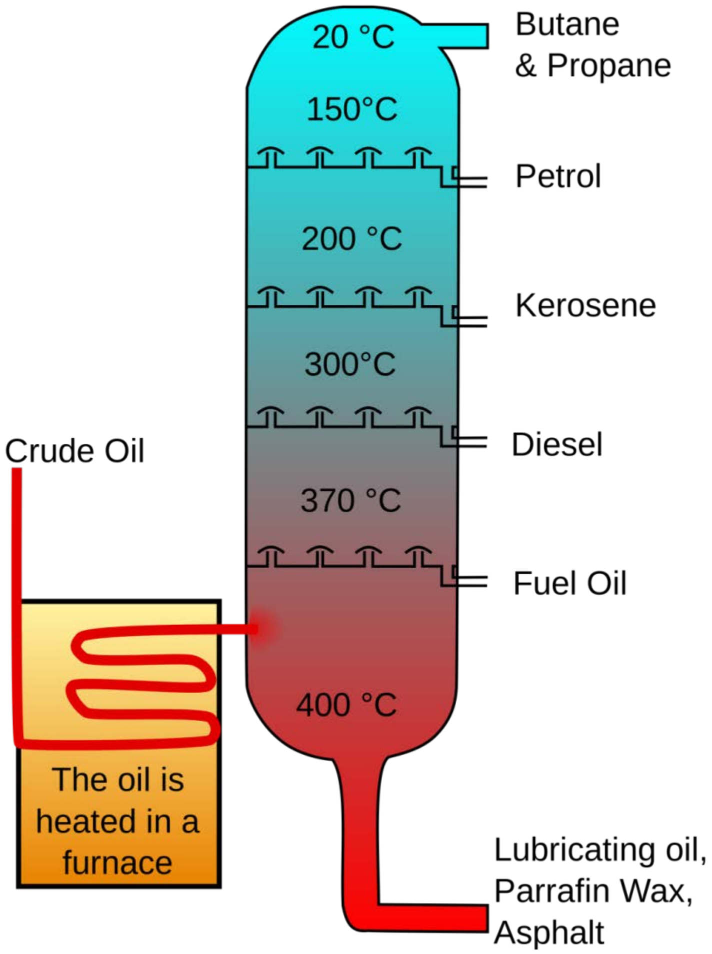


Figure 27 Simplified shale of oil distillation process

Petroleum and its fractions are characterized as dangerous cargoes. This fact is based mainly on the following characteristics.

4.2 Toxicity

Toxicity is the degree to which a substance can damage an organism. The damage can be local, for example a certain organ or the whole organism. A person can be intoxicated through many ways such as the *respiratory apparatus, digestive system,* and with direct *skin contact.*

The results of intoxication may vary due to the different level of toxicity of each substance or in case of same level of toxicity, in dissimilar organic systems. Irritation of the eyes and the respiratory system indicates primary signs of intoxication. Headaches, dizziness and discomfort are the following conditions in case of an infected person. In worse conditions when a person is exposed in high levels of toxic environment lack of senses and even death can take place.

These conditions may occur, even way below the flammable limit. The absence of sense of smell does not necessarily mean absence of gas. Toxic gases can sometimes disable the sense of smell and touch. (OCIMF, ICS, & IAPH, 1996)

Toxic fluids or soiled materials can provoke allergies or skin burns. On the other hand most of the toxic gases have higher density than air, thus can cause asphyxia due to the fact that they settle at the lower levels within a room and dislodge oxygen.

Interface with toxic can also lead to different types of cancer. In addition toxics can emit harmful radiation type a, b, c. To minimize the threat of health degradation in seafarers working environment as result of exposure to a toxic substance the AGGIH determined the amount of substance that a worker can be exposed without a risk of health disorders.

The TLV refers to the conciseness of harmful content in the measured area and its units are ppm for gases and milligrams per cubic meter (mg/m^3) for subatomic particles such as smoke, dust and mist. TLV is also expressed as Time Weighted Average (TWA).

Two major dissections of crude oil are *VOCs* and *PAHs*.

VOCs readily evaporate into the air, giving crude oil a distinctive odor. Some of them are extremely toxic and can cause many malfunctions to humans when inhaled. Nevertheless, the concern about VOCs in an oil spill for example quickly disappears after the first response due to the fact that oil rapidly loses its comprehensiveness of these substances.

In the other side of the coin, PAHs requires a different approach. PAHs in contravention with VOCs can persist in the environment over many years and affect sea ecosystem. Exposure to PAHs can cause direct death or can reduce the functionality of the immune system.

ex. Benzene (C_6H_6) is a natural ingredient of crude. For humans, it is claimed to be carcinogen. High toxicity substances like Benzene (C_6H_6) and Hydrogen Sulfide (H_2S) have strict TLVs of 1ppm and 5 ppm respectively. Some Hydrocarbons that are not included on the high toxicity list have higher TLV of 300ppm.

The permissible amount of time that someone can work in a toxic area is indicated on the ship by tables that consists the essence's TLVs followed by the time limit.

Table 11 Permisible working time corresponding to parts per million of a substance

PPM	TIME
300	480 min
1000	60 min
2000	20 min
7000	10 min
10000	1 min

4.3 Flammability

Flammability is the ability of a substance to burn or ignite, causing fire or combustion. Basically, it is inevitable for a ship to avoid the carriage of a combustible material, because even if we are not talking about a tanker or a LGC almost all the ships that are sailing nowadays use fuel engines and have flammable structure elements. When ignition occurs, it is not the liquid which burns but the evolved vapor. Different cargoes evolve distinctive quantities of vapor, depending on their composition and temperature. If the ignition occurs in an enclosed flammable environment, the raise off pressure can lead to an explosive rupture.

4.3.1 Fire

The presence of an unexpected fire, especially on the ship is a very serious event and therefore, everybody must be informed and ready to deal with situations like that. Cope with fire aboard is dissimilar to the process ashore in that allowance has to be made for the fact that the metal construction of the vessel allows fire to expand horizontally as well as vertically. Rise of temperature incites the auto-ignition of a material and therefore no direct contact of flame or spark is needed. In the Appendix Table 27 indicates the auto-ignition point of the most common chemicals and fuels.

Although the auto-ignition temperatures are almost for all substances away from ambient conditions in case of a fire, it is nigh certain that temperature will achieve this level. (R.Fristrom, 1995)

4.3.2 Tetrahedron of fire

The tetrahedron of fire is consisted by four components. If one of them is missing or can be isolated from the others, the combustion can't occur.

Oxygen: Air consists of 21% oxygen. When a fuel burns in plenty of air, it receives enough oxygen for complete combustion. Scientists believe that 11% of oxygen is required to start and sustain a fire. If oxygen is consumed from the fire process or can be blocked the fire cannot conserve.

Some fire detention techniques are based in that phenomenon. Tanks that contain inflammable materials like fuel tanks are usually filled with *inert gas* for explosion prevention. It is noticeable that even if a dam does not contain a flammable liquid and was empty for a long time can comprise a flammable environment within and a single spark can lead to an explosion.

Inert gas is not referred to a specific composition of gases but any mixture wherein there is not enough oxygen for combustion to take place. On a ship, a common source of inert gas is the exhaust gases from the main engine or a boiler. The gases from the exhaust pass through a scrubber and the demister and then through the IG blowers and the distribution system to every tank. Moreover an IG generator can be used. There will be a further analysis on inert gas system in the end of this chapter.

The tetrahedron of fire shows the key features that we should take into account in order to understand and be able to handle a fire event. Fuel can be any flammable material solid, liquid or gas.

The following characteristics of a fuel are briefly notified in order to minimize the threat of a fire.

Fuels as liquid do not burn. In normal temperatures, petroleum products create vapors which with a specific range of air portion can conduct an explosive mixture. The terms used to describe the flammability of a mixture are the U.E.L (upper explosive limit) and the L.E.L (lower explosive limit). Over the U.E.L the mixture is considered too rich and under the L.E.L is described as too lean. In both cases the mixture is unable to burn. For uniformity reasons a table with both L.F.L and U.F.L of the most common fuel substances is located at the end of the thesis in the Appendix.

4.3.3 Flash point:

The minimum temperature in which the surface of a liquid produces gases that can initiate fire.

4.3.4 Fire point:

The temperature in which the fluid can sustain fire. It is merely confused with the flash point but, it is greater than that temperature all most 3÷4 degrees.

4.3.5 Boiling point:

In that temperature, the liquid is turning into gas. The molecules become more active and gaps that are created between them get filled with bubbles of the evaporated fuel. In that temperature, the pressure of the bubble must be greater than the outside pressure. The boiling point of a liquid may vary due to different densities or external pressures. The heat required to activate this procedure is called "latent heat".

Table 12 Fuels and Boiling Points

Substance(Fuel)	Boiling point(F°)	Boiling point(°C)
Acetaldehyde	70	21,1
Acetone	134	56,7
Acetylene	-119,2	-84,0
ammonia	-27,4	-33
Benzene	176,2	80,1
Butylene	21,2	-6,0
Ethane	-127,5	-88,6
Ethyl Alcohol	172	77,8
Ethylene	-154,7	-103,7
Gasoline	100÷400	38÷204
IsoButane	10,9	-11,7
Isobutene	19,6	-6,9
Iso-Octane	243,9	117,7
IsoPentane	82,2	27,9
Isopropyl alcohol	181	82,8
Kerosine	304÷574	151÷301
Methane (Natural Gas)	-258,7	-161,5
Methyl Alcohol	149	65,0
Naphthalene	424,4	218,0
n-Butane	31,1	-0,5
NeoHexane	121,5	49,7
NeoPentane	49,1	9,5
n-Heptane	209,1	98,4
n-Hexane	155,7	68,7
n-Octane	258,3	125,7
n-Pentane	97	36,1
n-Pentene	86	30,0
Propane	-43,8	-42,1
Propylene	-53,9	-47,7
Toluene	231,1	110,6
Triptane	177,6	80,9
Water	212	100
Xylene	281,1	138,4

As it can be clearly seen, the boiling point can be way below the ambient temperature. In case of LNG (CH_4) the boiling point reaches 162 degrees below zero. Regulations indicate the cargo to be carried 3 points under its boiling point.

4.3.6 Explosion

When a fire takes place in an open area, the produced gases from the combustion procedure expand due to the heat and a smooth chain reaction can exist. In case of an enclosed area, the expansion of the heated gases is restricted. Rise of pressure, leads to higher flame speed and so to even higher pressure. That can result to the structural failure of the overpressure compartment and the explosion that will take place, is a fast relief of the gases in combine with a rapid, violent, uncontrolled release of energy.

BLEVE is the boiling liquid expanding vapor explosion, a phenomenon that occurs after the structural failure of a tank that contains flammable liquid caused by a surrounding fire. When a tank of fuel is heated due to an external fire the liquid inside starts to boil as it absorbs heat from the heated metal and thus the pressure rises. The expansion of the evaporated gases can activate the relief valves and so part of the gases escape the tank and therefore, the pressure decreases. The continuation of the external heating source makes the temperature rises again and in that case more bare metal (with no contact with a liquid to absorb the heat) is exposed to high temperatures. A structural failure to the wick points of the tank may occur and high pressure flammable material will get exposed to naked flames. The heat radiated is sufficient to ignite combustibles and cause burns, in great distance from the explosion. Also the explosion can turn the tank to a flying missile, traveling long distances away causing additional fires or damages in general.

4.4 Static electricity

The phenomenon of static electricity, when it happens, is enough to ignite a flammable atmosphere. When two materials get in touch, electrons can be transferred from one another and sometimes this action is followed by a visible spark caused by the neutralization of the two surfaces. To avoid that phenomenon all lines that transfer flammable liquids (cargo pipes) must be bond to the ship's hull. Whether earthing is not applicable, protective earthing conductors must be used. (DNV-GL, 2015)

The generation of static electricity cannot be prevented absolutely, because its intrinsic origins are present at every interface. (NFPA, "Recommended Practice on Static Electricity", 1988) Static electricity may occur when a liquid flows within a pipe or when it hits the solid surface of a tank. Under certain conditions static charged may occur within the liquid especially in case of hydrocarbons increasing the possibility of ignition in flammable vapor mixture.

Table 13 Accidents due to static electricity discharges

Name	Ship Type	Year
MACTRA	VLCC	December 1969
MARPESSA	VLCC	December 1969
KONG HAAKON IV	VLCC	December 1969
SURF CITY	Tanker	20 February 1990
FIONA	Tanker	31 August 1988
AMERICAN EAGLE	Tanker	27 February 1984
CIBRO SAVANNAH	Barge	31 July 1986

List of ship accidents caused by static electric or where static electric listed on top of the suspected reasons (Dyer, 1984)

Numerous industrial publications describe guidelines and techniques to avoid static discharges.

- "Protection Against Ignitions Arising out of Static, Lightning, and Stray Currents", (API)
- "International Safety Guide for Oil Tankers and Terminals", third edition, 1988, with May 1991 addendum, Witherby &Co. Ltd., London.
- American Waterways Shipyard Conference "Safety Guidelines for Tank Vessel Cleaning Facilities", June 1992, Arlington, Virginia.
- API Publication 2015 "Safe Entry and Cleaning of Petroleum Storage Tanks", fourth edition, January 1991, API, Washington, D.C.

The casualties due to that phenomenon were significantly decreased due to the implementation of the IGS and the COW system.

4.5 Anesthesia

Inhaling certain gases (e.g. ethylene oxide) may lead to loss of consciousness due to particular reactions with the neurological system. Anesthesia can be the cause of severe injuries like falling from heights, wounds from mechanical equipment and machines or other chain reaction hazards that can even lead to death.

4.6 Asphyxia

Asphyxia is a medical condition that may occur to a person and it is basically ineffective absorption of oxygen due to certain abilities of the cargo or the surrounding atmosphere in generally. The incapability of the blood to transfer enough oxygen to the brain can cause from a headache and lack of concentration, to loss of consciousness or even death. A fact worth to be mentioned is that a gas does not have to be toxic to cause asphyxiation. A brave example of this phenomenon is the respiration of inert gar in absence or low amount of oxygen. Argo, Helium and nitrogen are gases that are used for purging tangs and can cause asphyxiation regardless the fact that they are non-toxic.

Carbon monoxide (CO) inhalation is as a common cause of asphyxia. Monoxide is a very toxic gas produce basically through the combustion procedure of carbon-based fuels. It is almost undetectable thus it is odorless, colorless, and non-irritating at the beginning. Treatment from CO poisoning consists inhalation of 100% oxygen in order to permit the body to return oxygen to the normal levels.

Asphyxiation can be avoided by the careful inspection of the places we are about to visit and frequently monitoring of the working ambient with vapor and oxygen detection devices and monitors. Human cannot detect immediately the change of oxygen level and therefore, the use of technologies is required.

A new regulation aimed at protecting seafarers who need to enter enclosed spaces, by requiring ship's crew to carry portable atmosphere testing equipment onboard, entered into force on 1 July 2016. (source IMO)

4.7 Frostbite

Many cargoes are stored to be carried in very low temperature (e.g. liquefied gases). Direct contact with such temperatures will cause burn or frostbite. Exposed, non-insulated piles or a leak on a cargo tank can cause permanent damage to an organism. Proper insulation of the freezing system and cargo distribution as well as protective clothes are necessary to avoid unwelcome incidents. To treat a frost injury the injured part should be placed inside water 42÷44°C (degrees Celsius). The contact of such low temperatures can damage the structure of the ship leading to a brittle fracture.

5 Diseases and health disorders

Working on ships is listed among the most hazardous occupations. Changing of climatic conditions, handling of dangerous cargo and excessive occupation time schedule, make seafarers more vulnerable to health problems.

Despite the fact that seafarers go through health monitoring checks prior traveling, work onboard is a risky labor. If an incident occurs and special treatment is required doctors are not available (except passenger ships) and transportation to shore is most of the time impractical or impossible. Some serious disorders have been highlighted in many cases and led seafarers to long periods away from sea or in worst situations to severe health conditions or even death.

Cardio- vascular problems are commonly spotted among seafarers. This condition is normally a result of various factors such as stress, lack of leisure, diet, etc. Ships are built to operate with the minimum amount of crew and therefore, most of the time personal effort and responsibility lay down on the hands of a single seafarer. Health condition of personnel usually defines the level of difficulties that can put up with.

Musculoskeletal disorders are deficiencies related to muscular and skeleton structure of the body. These malfunctions are not unusual to seafarers and it is a common reason that keeps them away from seas for long periods. Musculoskeletal disorders can affect everyday life of a person and in the worst cases can cause permanent disabilities. Exercise and stretching is essential precautionary measures but lack of time and motivation after long shifts is an obstacle that has to be overcome.

Hand Arm Vibration Syndrome (HAVS). Vibrations from working tools usually used on ship's tasks can cause tingling or numbness of finger. That is a result of operating equipment for a long period beyond the safety limits of usage along with factors related with physical condition of the operator. Lack of awareness and improper use may lead to arm and wrist pains or permanent disabilities.

Some serious diseases related with the seafarers' environment are common threats of working onboard.

Pandemic and epidemic diseases are listed in the top threads for seafarers. Due to the nature of the sea transportations, ships usually visit ports located in areas, which rarely known to the modern world diseases, are a common phenomenon. Vaccination prior to sail to such places is a requirement but also acknowledge of the dangers and safe manners are a necessity. Always a danger of an unknown so far disease is present (i.e. EBOLA in West African) so safety precautions and healthy habits are required.

Hypertension also known as "high blood pressure (HBP)" is a phenomenon that blood pressure in the arteries exceeds the normal range. That malfunction can be caused by stress fatigue and unhealthy habits like smoking and alcohol. Loneliness and lack of leisure, situations commonly spotted in the seafarers' daily routine stimulate this malfunction. Engaging in physical activities is an effective ally.

Cancer is a deadly disease responsible for a great amount of fatalities among the globe. Especially seafarers must take additional safety measures due to the nature of their job. In a seafarer working environment periodically, carcinogen substances were spotted, such as asbestos. Although such materials were removed from ship construction new potential carcinogens such as beryllium (used on Product tankers), cadmium, lead as well as exposure to oil derivatives, toxics and chemicals pose a thread for development of various types of cancer. Additional threads from UV radiation and smoking incites the possibility of tumors' formations.

Sexually Transmitted Diseases (STDs) is also listed among the serious threads engaging in a seafarer's life. Unsafe sexual activities expose seafarer to fatal diseases with HIV marked as the most lethal among them. Awareness for the dangers and self-discipline can reduce the infections and fatalities owing to this cause.

Dengue fever is a disease that can lead to complication that may need hospital treatment and it is transmitted by mosquitos. It is found mainly in tropic regions like Africa, Asia and South America. Common symptoms are high fever, headaches, and muscle pain. In worst conditions, hemorrhagic complication may occur. Great attention should be given to avoid mosquito bites by mosquito balms and proper clothes since no vaccination is available for that disease.

Hepatitis C is a disease transmitted by contaminated blood. The disease is found worldwide and has little or even no symptoms of infection. However, in advanced stages may lead to develop a chronic inflammation of the liver. Treatment with non-sterile equipment can lead to contamination. Vaccination for this kind of disease is not available

Malaria is a disease caused by a parasite, which is transmitted through mosquito bites. Common areas with such incidents are found in Africa, Asia, the Middle East, Central and South America. Symptoms of that disease are: fever headaches, muscle pain, fatigue and vomiting which appear within 10 days. Visiting high risk areas preventive measures must be taken since the possibility of infection is increased and previous contamination does not provide immunity. Preventive medicine (Malarone) should be taken from 1 day before arrival and to 7 days after the termination of the stay according to Danish Maritime Authority. Preventive medicine is mandatory onboard and ports in high-risk districts.

Additional common diseases on seafarers which require vaccination procedures are mentioned in vaccination chapter 13.

6 Dangerous incidents and procedures

6.1 Enclosed spaces

Figure 28 Entering enclosed spaces

Enclosed spaces are not designed for continuous presence of workers and therefore inspection or maintenance operations are considered to be very dangerous activities. Lack of oxygen is one of the key components that create a deadly environment. Forced ventilation should always be provided with fixed or mobile vents to maintain sufficient level of oxygen during the whole process. An additional factor to be considered is the limited openings for entry and exit. That can cause a problem for transferring equipment in an out of the space and a serious obstacle in case of evacuation if a hazard occurs.

The person that enters an enclosed space must be well-informed and trained to cope with potential hazards. A consideration of the MSDS of the previous cargo is a good technique. Ensuring good-quality air is vital but is not the only precaution. First aid equipment must be tested and available near the entrance in case of an emergency.

The watchman at the entrance must be able to communicate with the person inside the enclosed space and the responsible officer. Approved communication UHF radio must be used, maintained in a good condition and fully charged. Regular communication is essential and shall not exceed a 15 min time gap. (ICS, 2015)

Sufficient illumination reduces hazards and enhances efficiency of work, during tasks inside low light locations. Portable lighting may apply when it’s possible but back up flash lights must always be carried.

PPE should always be in perfect condition and invariably be used in everyday tasks. Further information and description for personal protective equipment will be given in the sub chapter PPE of chapter 10.

6.2 Man over board

Figure 29 Man over board

The accident of man overboard is not an extraordinary phenomenon if we consider the uncertainty of sea environment. Water on deck and working in open weather can lead to such incidents. Therefore, good seamanship and constant vigilance should always take place prior as well as in case of a M.O.B.

Immediate actions must be performed when a person fall into the sea to maximize the chance of rescue and survivability. Releasing the lifebuoy that is equipped with light and smoke must be the first action to be taken in order to be able to mark the rescue area. Informing the Master from which side the person fell is a necessity in order to directly engage the steering gear and make a turn to the same side in order to avoid hitting the victim with the propeller. Putting a mark on the GPS system allows monitoring the rescue area. Rise of internal and external alarms will promptly inform every individual for the situation in order to perform his designed task or stay alert for further actions to be made. One of the most important factors for someone's rescue is to be visible from the ship's lookouts. This can enhance the effectiveness of the rescue operation and save valuable time. Further actions to be made are: record the time of the event, broadcast an urgency message to ships in the vicinity and preparer the rescue boat.

The conditions which such event can take place may vary and crucial for the saving operation outcome. The temperature of the water affects the chance of survival and also indicates some of the treating procedures when the person is rescued. If the incident happens at night, the localization of the person is extremely difficult. Infrared cameras are used mainly on cruise ship and rescue boats to enhance night detection but rescue at night is still questionable. Good seamanship and safety precaution are the best choices to reduce hazards.

6.3 Total blackout

“Deadship” condition as described by IMO is a condition that everybody on the ship hates. Total blackout is one of the conditions that affect the entire ship and can “freeze” the whole ship within seconds. (UK_P&I_CLUB, 2012)

International maritime regulations (e.g. SOLAS), require at least two generators for a ship's main electrical power system. Ships are designed mainly with three generator sets. One carries the main load, the second one is standby and the third is used on ports and in emergency conditions. A fire incident can be followed by a blackout. Whether the **fire** origins are electrical malfunctions either other causes if the main switchboard is affected a total blackout will take place. In many cases, a **generator’s malfunction** can lead to a total blackout. The source of the problem can be found in fuel pump failure or the lube oil pressure loss. As it is already mentioned a second generator in standby mode will take the load. Variations in times can permit a blackout.

Heavy loads are dangerous regards the normal function of a generator. If the system overloads, and the power needed exceeds the available power, likely the system will bent down.

The main engine is the source that powers the entire ship. **Main engine failure** or **lack of fuel** by means of insufficient allowance will breach the normal function of the ship. Figure 30 indicates the main reasons for a blackout and the key features of each cause.

In case of a blackout a series of actions must be made. Informing the Master about the situation is the first step. The alert of the chief engineer, responsible for the engine room operations is also required. Although a total blackout is a difficult situation and can be followed by serious hazards the whole situation must be handled without panic.

Effective communication between the bridge and the engine room is essential in order to correctly estimate the damage and properly handle the situation. Careful attentions to alarm’s and running the standby generator are on top priority.

The time of the incident must be recorded. Lookouts must check for ship or potential collision objects in the vicinity. All crew and passengers must be informed. OOW must set the VHF to channel 16/70 and broadcast an urgency message to nearby ships.

An estimation of any damages during this incident and the consideration of a tug needed must be performed by the Master. In the following diagram illustrates different tasks of the Master, officer on the watch of bridge (OOWB) and officer on the watch of engine room (OOWE) during a blackout event.

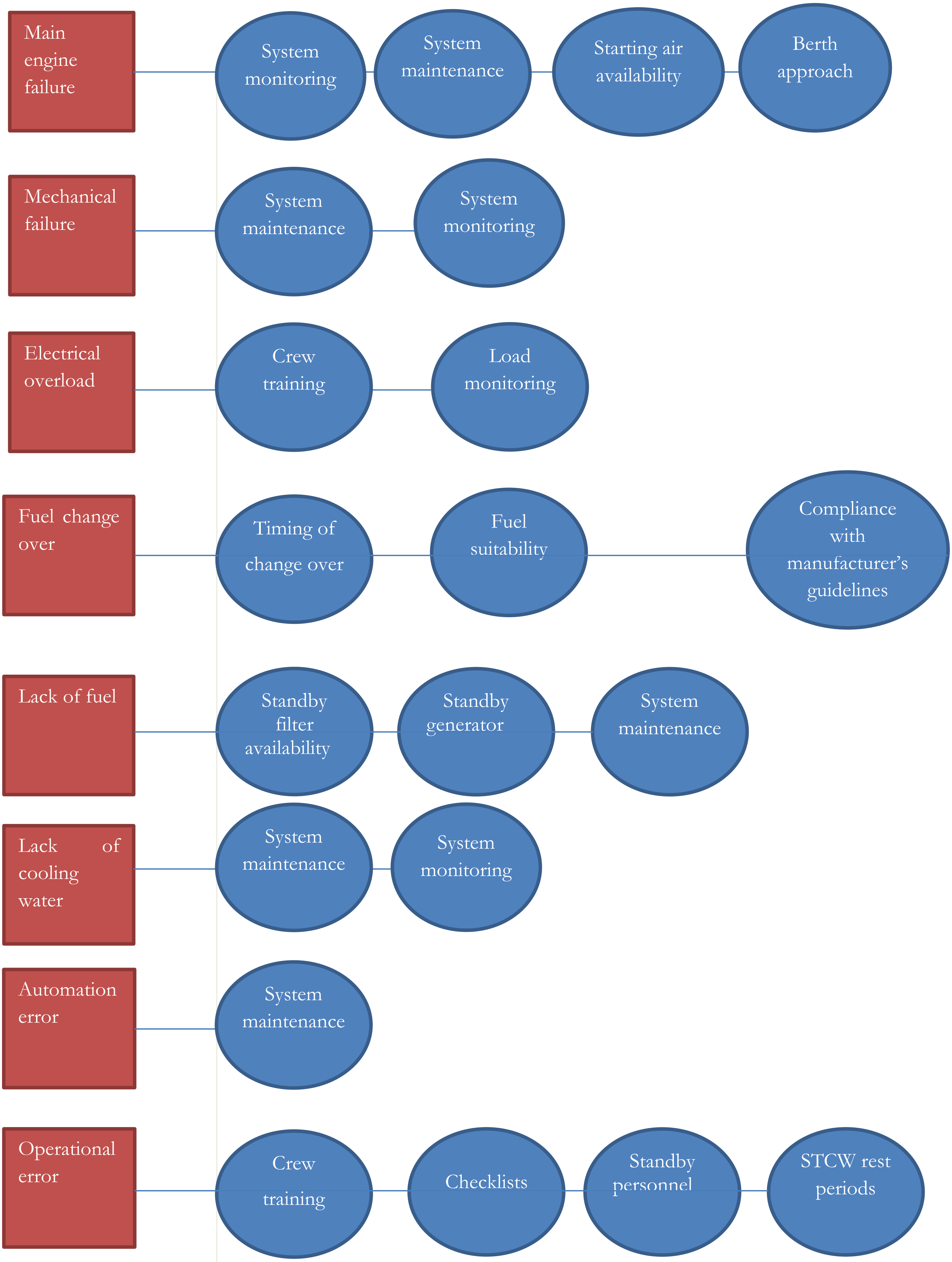


Figure 30 Potential causes of blackout

Sometimes blackout happens during maneuvers or sailing in narrows waters. In that case, the ship can be in dire straits threating also the safety of other moored vessels or bridges. In serious cases an evacuation procedure may follows. [18]

The performance of the **emergency generator** is very important. The emergency generator is located above the upper most continuous deck and must be capable of supplying power for a period of 18hrs for a cargo ship or 36hrs for a passenger ship.

The emergency switch board is located at the same space the emergency generator is located. According to SOLAS regulations, the emergency generator must be able to start automatically after 45 seconds of system's failure.

Table 14 Emergency generator requirements

Emergency Generator Requirements SOLAS II-1(74/78)	
Starting E.G	• Capable to start in cold condition at a temperature of 0°C (if the temperature is below zero a heating facility must be provided) • Must be equipped with an automatic starting system
Starting mechanisms	• The primary starting mechanisms is a battery which must be fully charged and able to provide three consecutive starts • The secondary starting system may be pneumatic or hydraulic and capable of providing 3 serial starts within 30min
Energy source	Emergency generator must have an independent power supply
Location	Above the upper most continuous deck
Operation time	18hrs for a cargo ship or 36hrs for a passenger ship
Respond time	Be able to automatically start after 45 seconds
Failure indications	In case of an unsuccessful start, indication must be available
Operation margins	Should be able to operate in full range even if the ship is inclined at the angle of 22.5 degrees vertical or 10 degrees longitudinal
Application	Must be able to fully supply all mechanisms that are essential in case of an emergency

It is obvious that in case of an emergency not all the facilities of the ship will be available. Only the most important and essential devices regard the ship's safety and functionality will consume the disposable energy. The machines and mechanism supported by the emergency generator are listed below:

- Emergency Transformer
- Local Fire Fighting Main Panel
- Fire Detection System Control Cabinet
- Navigational Light Ind. Panel
- E/R Control Console
- Smoke Detection System
- Emergency D/G Room Lighting
- UPS for CO2 Release Alarm System
- Public Address Main Unit
- Bridge Control Console
- Distribution board
- M/E Control System Power Supply Unit
- Battery Charger for Rescue Boat
- No.2 Steering Gear
- Emergency Fire Pump
- Emergency Fire Pump Room Fan
- Local Fire Fighting
- Main Air Compressor
- Breathing Air Compressor

6.4 Piracy

Figure 31 Pirates attack

One of the dangers that a ship must be ready to face is the threat of piracy/armed robbery. Piracy is a disease for the shipping industry that has not treated yet with a proper manner. Therefore, a lot of disadvantages have been added during the travel of a merchant ship. **Human losses,** engaged in a piracy event, are the most serious defects. It is well known that member of the crew can be taken as hostages to claim ransoms. Even if the person is not killed or injured during the process the whole incident is a **tragic experience** that will probably affect the seafarer's life. A not so obvious consequence for the shipping industry is the **reduction of qualified people** that work onboard. Safer jobs in shore become more attractive.

Money losses as well as environmental damages are listed on the top negative points due to piracy presence. The most affected are mainly smaller companies involved in shipping. Cargo loses are not only costly but also in many cases, cause a serious threat to environmental protection.

Looking at a seafarer's working schedule, an **additional burden** has been added to the daily tasks. Extra procedures and precaution measurements are required prior and during the passage of a high risk area.

Fatigue due to the preparations throughout the ship and additional stress are worth to be mentioned as major defect of the piracy presence.

Some regions around the world are characterized as riskier areas due to the presence of pirates. More notably the following ones:

- SOUTH EAST ASIA AND INDIAN SUB CONTINENT
  - **Bangladesh**
  - **India**
  - **Indonesia**
  - **Malaysia**
  - **Singapore Straits**
  - **South China Sea**
  - **Vietnam**
- AFRICA AND RED SEA
  - **Nigeria**(**Lagos and Bonny river**)
  - **Benin(Cotonou)**
  - **Gouinea (Conakry)**
  - **Cameroon(Douala Outer Anchorage)**
  - **Gulf of Aden/Red Sea**
- SOUTH AND CENTRAL AMERICA AND THE CARIBBEAN WATERS
  - **Brazil(Vila do Conde**)
  - **Peru**
  - **Venezuela**
  - **Haiti**
- REST OF THE WORLD
  - **Arabian Sea / Off Oman**
  - **Indian Ocean**
  - **Iraq**

(source ICC)

The type of the incident may vary and in order to have a more comprehensive approach, we can point out some specific features.

- **Near/far of shore**

Ships have been under attack near shore. Pirates using small and fast boats, that are usually undetected from radars, attempt to attack a commercial ship. Therefore, vessels crossing the mentioned areas are recommended to take additional precautionary measures and keep strict 24 hours visual and radar anti-piracy watch using all available means. The crew should look out for small suspicious boats approaching their vessel.

In the other side of the coin we have attacks 1,000 nm away from the coast. Normally the small crafts that were mentioned before cannot easily operate in such long distances but in collaboration with a mother vessel (usually a hijacked fishing vessel) pirates can expand their range and surprise the transiting ship.

- **Target group**

  - Money, jewels, and valuables on the ship
  - The entire ship can be abducted and be kept for ransom or even its own cargo
  - Seafarers kidnaping

  *A combination of the above incidents can occur

- **Condition of the ship during attack**

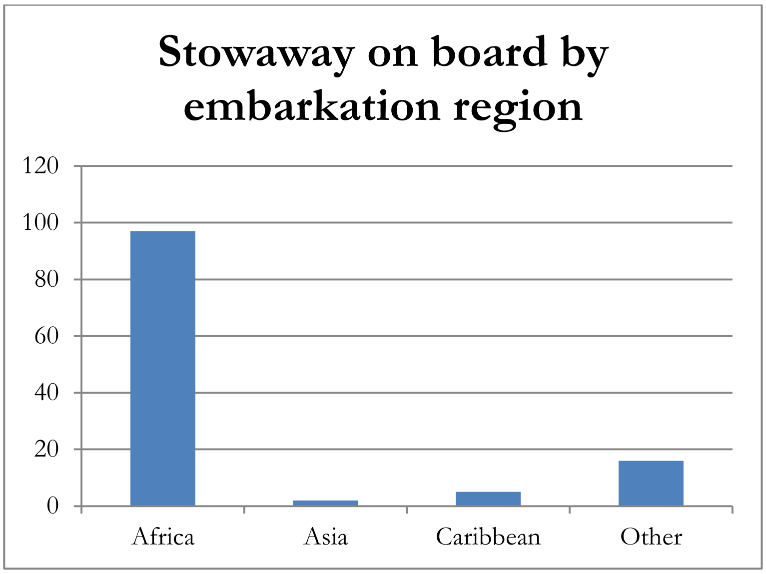
During an attack, the ship can be on its way, with small or medium speed. Early detection of a converging craft can allow the captain to speed up and make the vessel's approach more difficult. In the other hand, a lot of attacks are also reported while a ship is in anchorage.

6.5 Stowaways

IMO defines a stowaway as follows: “Stowaway means a person who is secreted on a ship, or in cargo which is subsequently loaded on the ship without the consent of the shipowner or the master or any other responsible person and who is detected onboard the ship after it has departed from a port, or in the cargo while unloading it in the port of arrival, and is reported as a stowaway by the master to the appropriate authorities.”

A discovery of a stowaway onboard is an incident that must be treated with composure and awareness through standard procedures. **Tight security and inspection prior to the ship’s departure** can be a small problem compare to the discovery of a stowaway during the ship’s middle travel. However, in most cases, stowaways are found after departure.

Table 15 Stowaways’ embarkation region (data source IMO 2014)

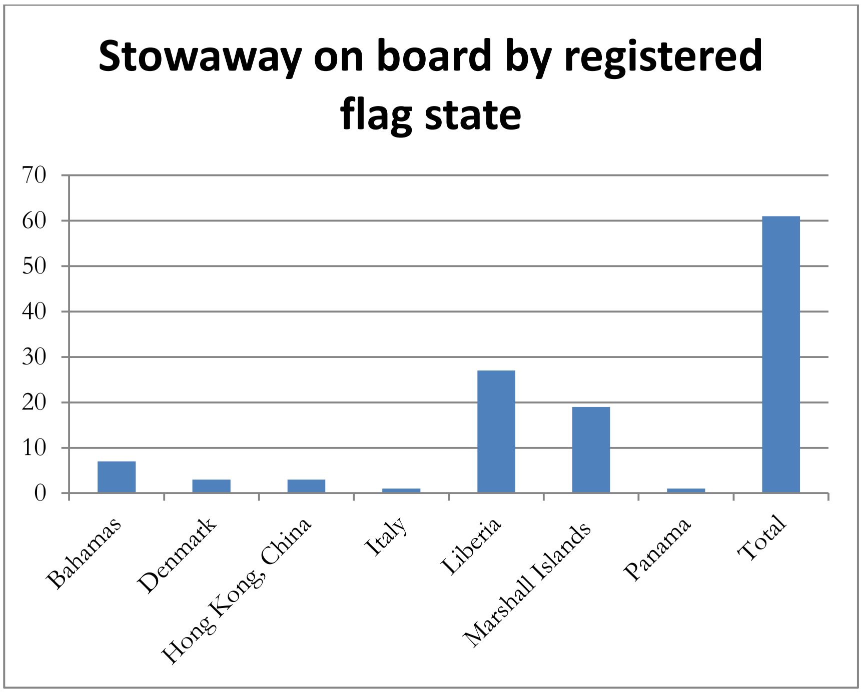


(Total of 120 incidents)

As it can be clearly seen in the chart above, the majority of stowaways illegally boarded on vessels are located in Africa. According to P&I clubs a stowage’s return, has an average cost of 38500$ followed by many problems and difficulties for the crew and the ship owner. In most cases, the company has to pay for all repatriation cost of the person.

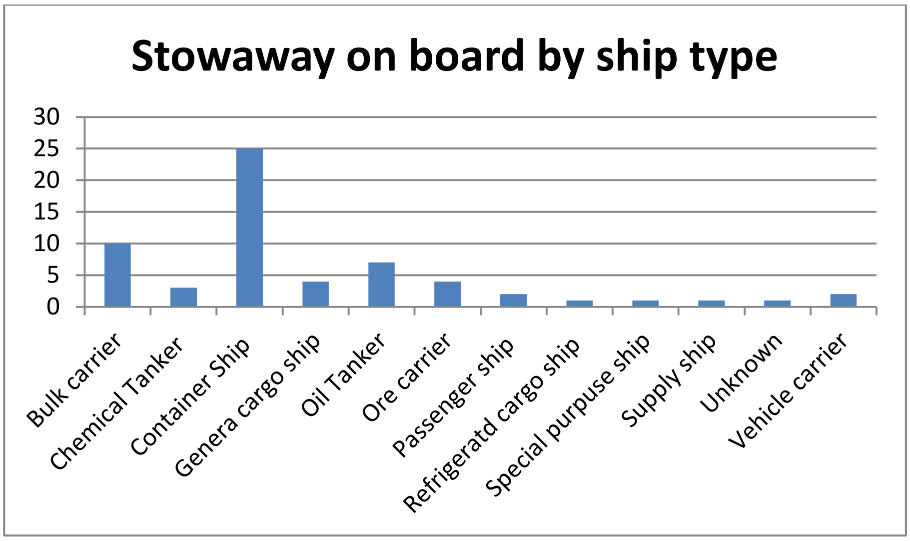
The flag states reported to be involved in stowaway cases are shown in next table chart.

Table 16 Stowaway per flag (data source IMO 2014)



Information of the person's identity and how he got onboard must be obtained, if possible, during a conversation. If the stowaway is discovered near the departure port returning is a considerable choice with respect to the vessel's time schedule. Any identification document shall be retained in a safe place until disembarkation. In most cases, the delivery of a stowaway with no identification documents is extremely difficult. In case of late discovery, the stowaway should be kept in a safe locked room, to avoid jeopardize the safety of the crew, the vessel, as well as his own. The types of ships commonly involved in stowaway incidents are shown in Table 16.

Table 17 Stowaway per ship type data source IMO (2014)



All actions taken should be made with respect to safety and humanitarian principles. Although P&I clubs advise to not overly befriend with the stowaway. The company and the P&I club must be informed as soon as possible. Stowaways usually use the ruder trunk to sneak into the vessel because in several conditions, it is easy accessible with small crafts during mooring.

Figure 32 Rudder recess (stowaways)

Weapons, drugs or stimulus medicines should be confiscated by the Master and kept in a safe place. Food, toilet visit and baths should be provided during the travel. Security shifts shall be formed to watch over the person. In case of multiple stowaways, they must be kept in separated rooms if possible and interviewed individually.

A stowaway incident can cause serious problems to a ship normal operation as well as delays additional costs and problems with the port state control. IMO to assist masters in the resolution of stowaway problems and developed the Stowaway Focal Point (SFP). However, an investigation into potential hiding areas prior departure may avoid troubles caused by stowage boarding.

6.6 Evacuation

Figure 33 Evacuation process

Modern vessels are created in such a way, that the probability of dangerous events is minimized. Even when such situations occur, safety mechanisms are fitted onboard to deal with almost every kind of trouble. Collision, contacts, groundings or structure failure are confined by advanced navigation systems, proper design and decent maintenance. Good seamanship is always the cornerstone of all activities.

An accident is considered to be a "successful" event whereas, in order to happen numerous of safety mechanisms must be overcome. When that happens and the integrity of the ship is compromised, the evacuation of the ship may be the safer option. Therefore, a vessel is equipped with equipment that will allow crew and passengers to evacuate the ship in case of an emergency. Cargo ships even if they carry dangerous cargo are considered to be safer vessels than a passenger ship since the legislation requires more safety equipment per personnel. In addition evacuation process of a small amount of people like the crew members of a cargo ship is more feasible compared to a passenger ship. Moreover crew members are regularly trained through drills that simulate the evacuation process unlike the passengers. However for every type of ship proper procedures are develop to ensure a safe evacuation.

An evacuation on a passenger vessel takes into account several parameters considering the evacuation time, the number of the passengers, the paths that people should follow as well as special conditions (ex. Fire) that may occur during the incident. The evacuation time can be divided into smaller periods:

The **awareness time (A)** as defined from IMO "*is the time it takes for people to react to the situation. This time begins upon initial notification (e.g. alarm) of an emergency and ends when the passenger has accepted the situation and begins to move towards an assembly station*" In different scenarios during an evacuation analysis the awareness time is considered to be 10min for night and 5min for day time scenarios.

The **travel time (T)** *"is defined as the time it takes for all persons onboard to move from where they are upon notification to the assembly stations and then on to the embarkation stations."* The travel time is affected from the structure of the ship (doors, corridors, stairs, etc.) as well as how far is the nearest master station. The speed of the passenger is estimated similar to shore evacuation and it is highly affected from the density of each pathway. The density of each path is defined as the amount of people per square meter (p/m^2). The travel time is one of the four parameters of the total evacuation time and therefore, it can be clearly seen that design aspects such as the width of the corridors and doors are critical. The specific flow according to IMO *"is the number of escaping persons past a point in the escape route per unit time per unit of clear width W_c of the route involved."* Typical values concerning the referred parameters are shown in

Table 18 Stairs and corridors evaccuationspeed and flow

Type of facility	**Specific flow Fs** (*p/(ms)*)	**Speed of persons S** (*m/s*)
Stairs (down)	0,54	1,0
	1,1	0,55
Stairs (up)	0,43	0,8
	0,88	0,44
Corridors	0,65	1,2
	1,3	0,67

(NFPA, "SFPE Fire Protection Engineering Handbook,2nd edition", 1995)

Embarkation time (E) *and* **launching time (L)**, are defined as "the time required for abandonment by the total number of persons onboard. (IMO, "Interim Guidelines For Evacuation Analyses For New And Existing Passenger Ships", 2002)

The whole calculation process simulates a hydraulic network in which the pipe lines are the corridors and the stairs and the liquid are the people. For Ro-Ro passengers, the evacuation must be performed within an hour (60min) and for passenger ships with more than three vertical zones must be completed within 80min.

$A + T + 2/3\ (E + L) \leq n$ (SOLAS regulation III/21.1.4.)

In addition the sum of E+L must not exceed the period of 30 minutes.

7 Rules, conventions and safety systems

A serious number of conventions have been placed around the different threats of a ship's travel showing a clear need for confrontation against any potential hazard. Although there is one side of the coin that believes that some regulations are not aiming the core of a problem in the way they are applied and only add paperwork to the so far busy labor of a seafarer and that of the shipping company. In addition slow ratification of adopted Conventions compromises safety research that has been already done. IMO has currently 171 Member states, but according to IMO, 49 of them have accepted 10 or fewer of the most important convention or protocols. This might be seen as a matter of a minority of states that don't vote for the implementation of IMO conventions but in a closer look, it can be clearly seen that the approximately 60% of all state members have approved less than half of safety precautions. Key players within the shipping industry as: ICS, Intertanko and Intercargo point out this situation as a serious problem. Member States of IMO are not obliged to apply the conventions into their legislation and there is not a required amount of adopted conventions in order to be a Member state of IMO. Below there is a list with a number of IMO conventions that are highly ignored by the majority of States.

Nairobi International Convention on the Removal of Wrecks, 2007 (NAIROBI WRC)

The convention adopted in 18 May of 2007 is focused on the prospective hazards that a ship wreck may cause to operating vessel and the aquatic environment and provide a uniform international legal basis for removal of wrecks located in seas. Key aspects covered in this section are: reporting and locating wrecks, criteria for determining potential hazards as well as removal procedures, cost responsibilities and resolution center facilities. Despite the importance of the thread cause by ship wreck, this convention like others of similar momentousness took at least 8 years to enter into force in 14 April 2015.

International Convention on Liability and Compensation for Damage in Connection with the Carriage of Hazardous and Noxious Substances by Sea (HNS)

On 3 May 1996 the HNS convention was adopted but never entered into force due to lack of ratification. It was an effort inspired by the successful model of the Civil Liability and Fund Conventions which cover pollution damage caused by spills of persistent oil from tankers. The convention covers the wide field of substances defined as HNS such as oils, liquefied gases and solid bulk materials related with chemical hazards as well as dangerous cargos carried in packaged. One of the major aims is defining a mandatory insurance that will cover the cost of in case of an accident as well as claims from the funds from the shipowners in case of violation of insurance policy. The convention was superseded by 2010 HNS Protocol but has not yet entered into force despite consistent efforts from IMO.

The Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships

The Hong Kong Convention adopted in 15 May 2009 is another international conference result concerning Health and Safety of humans, by means of safe recycling methods. At the end of the life cycle of a vessel it is sold to a breaking yard in order to reuse most of the construction material. Hong Kong convention includes regulations about hazardous substances like asbestos, heavy metals, ozone depleting substances etc. that can cause damage to human life with direct contact or environmental degradation through the recycling process. Key features of this convention are the requirement of an inventory in which all the hazardous materials of the ship's structure will be included as well as a prescheduled recycling plan for the ship. This convention according to IMO will get into force "24 months after ratification by 15 States, representing 40 percent of world merchant shipping by gross tonnage, combined maximum annual ship recycling volume not less than 3 percent of their combined tonnage"

International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM)

One of the most recent conventions points out the need of prevention of the potentially devastating effects due to the spread of invasive harmful aquatic organisms carried by ships' ballast water. On 13 February 2004, IMO adopted the "*International Convention for the Control and Management of Ships' Ballast Water and Sediments*" which requires basically an installation of a ballast water treatment facility onboard and a ballast water treatment plan. Ships should keep a record concerning the obtained ballast and apply a proper treatment prior discharge.
Until now, its requirements are not obligatory, due to the fact that a few number of countries endorsed it. BWM will into force: 12 months after ratification by 30 States, representing 35 percent of world merchant shipping tonnage.

Three of the above-mentioned conventions have not yet entered into force, despite the fact that they are referring to important Health and Safety matters. In addition slow ratification of the adopted conventions is obvious since the average time for a convention to enter into force is approximately seven years. A list of IMO conventions is included in Appendix I.

MARPOL

One of the most important measures of IMO was the International Convention for the Prevention of Pollution from Ships (1973) that covers not only accidental and operational oil pollution but also pollution by chemicals, goods in packaged form, sewage, garbage and air pollution.

SOLAS creation was a response to the major impact that the sinking of RMS Titanic made to the world back in 1912. The 1914 treaty never entered into force due to the outbreak of the First World War. Many years later the International Maritime Organization in 1960 took the responsibility of the implementation of SOLAS convention and five years afterward in 1965 SOLAS entered into force. New versions of SOLAS were created through the years revising or adding sections for Safety of Life at Sea. Currently, SOLAS includes the following chapters:

C*hapter I* - General provisions
Chapter II-1 - Construction - Subdivision and stability, machinery and electrical installations
Chapter II-2 - Fire protection, fire detection and fire extinction
Chapter III - Life-saving appliances and arrangements
Chapter IV - Radiocommunications
Chapter V - Safety of navigation
Chapter VI - Carriage of cargoes
Chapter VII - Carriage of dangerous goods
*Chapter VII*I - Nuclear ships
Chapter IX - Management for the safe operation of ships
Chapter X - Safety measures for high-speed craft
Chapter XI-1 - Special measures to enhance maritime safety
Chapter XI-2 - Special measures to enhance maritime security
Chapter XII - Additional safety measures for bulk carriers
Chapter XIII - Verification of compliance.
Chapter XIV - Safety measures for ships operating in polar waters.

ISM Was adopted by IMO on 23 November 1995 and entered into force in 1th of July 1998. The International Safety Management Code was created to provide a global standard for the safe management and operation of ships. According to the ISM code every shipping company in order to operate has to obtain the Document of Compliance (*DOC*) which is provided by a state authority or a certified entity. A copy must be available on every ship. In addition, every ship must have a safety management certificate that ensures the company has a safety management system (SMS) and each ship is operating according to this.

CSR Common structural rules were developed from IACS in order to fulfill the need for uniformity in ship construction. CSR find application merely on oil tankers and Bulk carriers over 90m. Some Vessels listed as bulk carriers like Ore Carriers are not required to comply with CSR. (LIoyds, 2014)

ISPS The International Ship and Port Facility Security Code, that entered into force on 1st of July, 2004 aimed to create a framework of standardized procedures to enhance security for ship and port facilities. The code has one mandatory and one optional part. The first part (mandatory) includes three set of security measures corresponding to three different security levels. The second part (optional) includes suggestions for the implementation of the measures listed in part I and guidance for dangers that can potentially threat a docked ship.

IMDG The International Maritime Dangerous Goods code, published by IMO, refers to the unsafe cargo carried out through the sea. However, the code does not include all the details about packing procedures or response after an incident including dangerous cargo. Those aspects are covered through other guides like MFAG and EmS guide.

- **MFAG** is the medical first aid guide who focuses on the diagnosis and guidance for treatment within the limits of the facilities available at sea.
- The **EmS** Guide provides useful information on Emergency Response Procedures for Ships Carrying Dangerous Goods.

Information on the treatment of illnesses, which are of a general nature and not predominantly concerned with chemical poisoning may be found in the *International Medical Guide for Ships* (**IMGS**).

ISGOTT

The International Safety Guide for Tankers and Terminals has the most complete treatment for hazards on tank vessels. ISGOTT is created by a consortium of the Oil Companies Marine International Forum (OCIMF), the International Association of Ports and Harbors (IASH), and the International Chamber of Shipping (ICS).

OPA Was formed due to the imperfections on previous "Acts" (Clean Water Act of 1977, *CWA* and Federal Water Pollution Control Act, *FWPCA*). The accident of Exxon Valdez On March 24, 1989 clearly showed major deficiencies associated with preventing, responding to, and paying for oil pollution incidents. The U.S. congress adopted many implementations to reduce potential hazards against spills with most notably the double hull requirement for ships entering the US territory.

OPRC Convention was adopted by IMO in 1990 after the Exxon Valdez disaster and entered into force five years later in May 1995. Main purpose of this convention is to restrain the effects of oil spills. A basic obligation of the parties is to have a pollution emergency plan as well as resources to cope with that kind of incidents. Mutual assistant between parties is also a requirement in order to effectively cope with oil spills. (Charlebois, 2012)

AFS Convention conducted in 2001 from the international Maritime Organization deals with the matter of harmful substances in anti-fouling paints used on ships. Antifouling paints are used on ships to prevent sea organisms to colonize the vessel's hull causing additional resistance. Some compounds like TBT (developed in the 1960s) were super effective against growth of marine organisms on the hulls but remained in the sea killing sea-life. According to this convention state parties prohibit or restrict the use of harmful compounds like TBT that threat the environmental equilibrium and potentially enter the food chain.

8 Environmental protection

8.1 Pollution of the sea

Figure 34 Pollution of sea water

Pollution of the seas is covered thoroughly by the chapters of **Marpol**. Currently is consisted by six chapters including different types of pollution. The first five chapters are the following ones.

Chapter 1: "Regulations for the Prevention of Pollution by Oil" (entered into force 2 October 1983)

Chapter 2: "Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk" (entered into force 2 October 1983)

Chapter 3: "Prevention of Pollution by Harmful Substances Carried by Sea in Packaged Form" (entered into force 1 July 1992)

Chapter 4: "Prevention of Pollution by Sewage from Ships" (entered into force 27 September 2003)

Chapter 5: "Prevention of Pollution by Garbage from Ships" (entered into force 31 December 1988)

Additional conventions referring to the marine pollution have been introduced since then to complete or add topics that are not covered by the chapters of MARPOL such as the OPRC, AFS and the LC convention, etc. Full names of all the conventions adopted from IMO are listed in Table 29 of the appendix.

Since the development of iron ships, water started to be carried out in tanks in order to improve efficiency and stability requirements. A problem that occurred during this process was the carriage of harmful species, plants, viruses and bacteria inside tanks among with the ballast water that will later be discharged in various terminals. The adaptability and fast spreading invasive species create a thread to the biodiversity and can lead even to the extinction of certain species. Therefore, guidelines for the management of ship's ballast water were conducted in order to reduce that phenomenon. (IMO, "Proposal for an amendment of the regulations concerning the Oil Discharge Monitoring and control equipment (ODM)" , 2003). The BWM convention, adopted in 2004, covers that matter and will enter into force on 8 September of 2017.

The other aspect of oil derivatives and dangerous chemicals in ballast water that were discharge into the sea when the ballast was removed during the loading operation, is significantly reduced through the implementation of the much cleaner segregated ballast tanks. In case of *segregated ballast* tanks, ballast water is loaded on the vessel in tanks that are used only for the ballast condition and not for loading cargo or other substances as the do when *clean ballast tanks* are in use.

8.1.1 Particularly Sensitive Sea Areas

Due to the pollution from the operation of ships and in order to protect fragile environment IMO adopted patronizing requirements for some particularly sensitive sea areas.

The following PSSAS have been declared:

- The Great Barrier Reef, Australia (designated a PSSA in 1990)
- The Sabana-Camagey Archipelago in Cuba (1997)
- Malpelo Island, Colombia (2002)
- The sea around the Florida Keys, United States (2002)
- The Wadden Sea, Denmark, Germany, Netherlands (2002)
- Paracas National Reserve, Peru (2003)
- Western European Waters (2004)
- Extension of the existing Great Barrier Reef PSSA to include the Torres Strait (proposed by Australia and Papua New Guinea) (2005)
- Canary Islands, Spain (2005)
- The Galapagos Archipelago, Ecuador (2005)
- The Baltic Sea area, Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland and Sweden (2005)
- The Papahānaumokuākea Marine National Monument, United States (2007)
- The Strait of Bonifacio, France and Italy (2011)
- The Saba Bank, in the North-eastern Caribbean area of the Kingdom of the Netherlands (2012)
- Extension of Great Barrier Reef and Torres Strait to encompass the south-west part of the Coral Sea (2015)

In those areas special requirements with respect to environmental protection have been taken. For example, based on the Annex I- "Regulations for the Prevention of Pollution" by Oil of MARPOL all discharges of oil or oil mixtures are prohibited unless the following criteria are fulfilled:

a. The ship is moving and the oil content of the effluent without dilution does not exceed 15 parts per million.
b. The oily mixture must be processed through an oil filtering equipment.
c. In addition, the oily mixture does not originate from cargo pump-room bilges.
d. Oily mixtures are not mixed with oil cargo residues.

8.1.2 Discharges and activities in port

Ports are areas were the vessels' courses converge and therefore that gathered pollution from ships' operation led to certain legislation in order to decrease the harmful effects. Some common restricted discharges are listed in the following paragraphs.

Deck washdown is not allowed in port unless no noxious substances like oil, trash, paint or other debris are involved. Cleaning and painting is allowed in the Ports but must follow specific BMPs. Spray-painting equipment, biocide-based antifouling paint, as well as sandblasting are not allowed. In addition cleaning operations in case that biocide-based paint or restricted from the state of the port material have been used are not allowed.

Ballast water shall never be discharge without proper treatment. Bilge water is prohibited from being discharged into Port's waters. Exhaust gas scrubber washwater can be discharged under the terms of no oil content is included. To avoid confusion, no sludge generated from the exhaust gas scrubber must be discharged. Sea cooling water shall preferably be discharged when the vessel is on the move. If the discharge is performed in the port no oils or metal alloys must be contained and the discharge rate must be as low as possible to minimize thermal impacts. (Port_of_Long_Beach_and_LosAngeles, 2012)

8.1.3 Recycling of ships

Figure 35 Alang, Gujarat, India demolition yard

The Hong-Kong convention that took place in China, May 2009 tries to minimize the threat to human's health and environmental protection through recycling procedures of a ship. The convention conducted a list of hazardous materials, which are prohibited in demolition places. Ships must carry an inventory with all the precarious materials on the ship and in addition they should cross through surveys during the ship's life time and also prior to the recycling procedure. Shipyards also must be able to assure that the procedure they apply complies with the regulations of the convention.

Recycling of ships, in a sound manner, is a "green" industry. Almost nothing goes to waste. Most of the parts are reused ashore. If we compare the energy required to refine most of the recycled parts, with a brand new component, we see a reduction of 70% in energy consumption.

To put it all in a nutshell, in order for the recycling industry to be characterized as "green" the practices and working processes applied from the yards should be certificated with international standards and techniques. The majority of shipping leader States based on the GRT and demolition activity should embrace the principals of the convention. The biggest demolition yards are listed in Table 20.

Table 19 Demolition Yards

Biggest Demolition Yards	
Name	**Location**
Alang Ship Breaking Yard	Bhavnagar area**, India**
Chittagong Ship Breaking yard	Fauzdarhat area, **Bangladesh**
Gadani ship breaking yard	Karachi,**Pakistan**
Changjiang Ship-Recycling Yard	Jiangsu Province, **China**

8.2 Pollution of the air

Figure 36 Air pollution

The Annex VI of MARPOL, which entered into force in 2005, seeks to minimize airborne emissions from ships (SO_x, NO_x, ODS, VOC shipboard incineration)

8.2.1 ECA zones

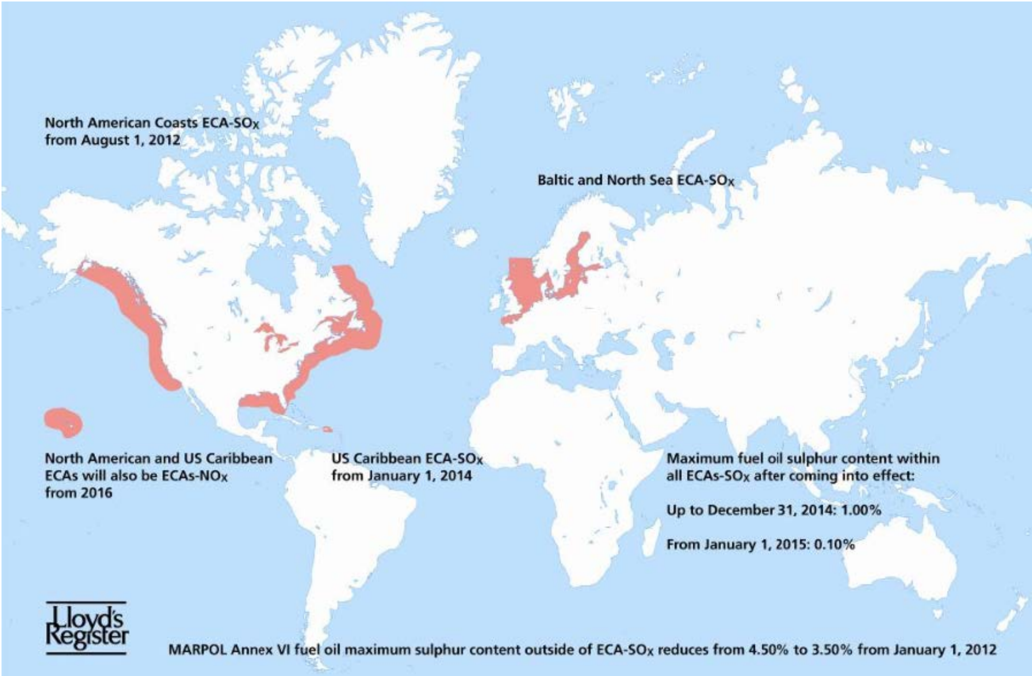


Figure 37 ECA zones source Lloyds

IMO and MARPOL 73/78 convention set limits on sulfur emission during the operation of a ship and point out certain areas that are consider as more vulnerable due to the enhanced ship traffic and they are showed with red color in the picture above.

More specific they are the following ones:

- Baltic and north Sea Eca-SOx
- US Caribbean Eca-SOx from 1 January , 2014
- North American Coasts Eca-Sox from August 1 , 2012

Currently ships are required to meet the 0.10% limit within the above mentioned Ecas and the barrier of 3.5% outside of them. The latter will change either in 2020 or in 2025, requiring 0.5% limit and that is a subject under consideration that will be defined in 2018. In the meantime more areas may be declared as emission control areas such as the Aegean Sea, Norwegian Sea and Sea of Japan.

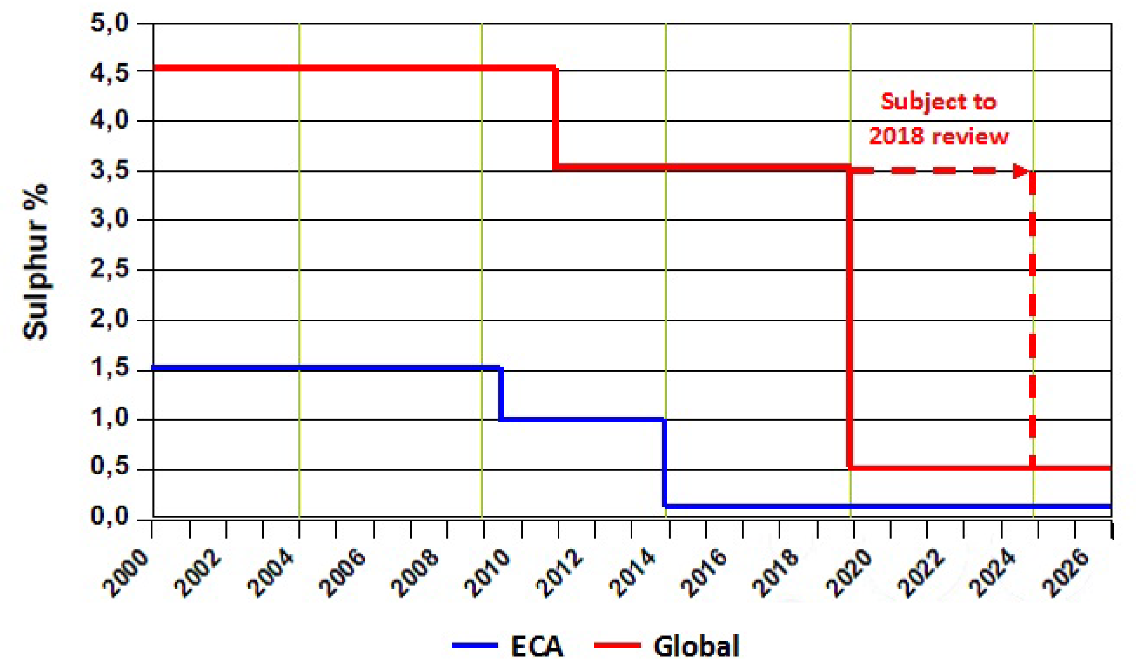


Figure 38 Permissible sulphur emissions (source MARPOL Annex VI, Regulation 14)

In December 2016 China's Ministry of Transport announced the set up of three new ECA areas in their territory and those are the Pearl River Delta, the Bohai-rim waters and the Yangtze River Delta. In the latter, a 0.5% emission is compulsory until the end of 2017, from one hour after arrival till one hour prior departure. The requirement will become mandatory during the whole duration from 2018 and in 2019 will meet the 0.1% prerequisite.

*North American and US Caribbean Sea ECAs will also be ECAs-NOx from 2016. In addition to the above, from 2016 new engines on vessels operating in the US Caribbean Sea ECA (and the North American ECA) must use emission controls that achieve an 80% reduction in NOx emissions to comply with the MARPOL annex VI SOx and NOx emission.

These standards are set for diesel engines based on the engine's maximum operating speed:

Tier	Ship construction date on or after	Total weighted cycle emission limit (g/kWh) n = engine's rated speed (rpm)		
		n < 130	n = 130 - 1999	n ≥ 2000
I	1 January 2000	17.0	$45.n^{-0.2}$ e.g., 720 rpm – 12.1	9.8
II	1 January 2011	14.4	$44.n^{-0.23}$ e.g., 720 rpm – 9.7	7.7
III	1 January 2016*	3.4	$9.n^{-0.2}$ e.g., 720 rpm – 2.4	2.0

Figure 39 NOx emission limits

The alternatives for the marine engines in order to comply with the regulation are the following ones:

8.2.2 Scrubbers

The exhaust gas treatment is one of the solutions for reduction of sulphur emissions in the atmosphere. There are mainly two types of scrubbers in the market as they are described below.

- Open type scrubber

This mechanism uses sea water to wash the exhaust gases. The water is sucked up with a pump system from the sea chests and right after the water treatment is discharged back to the sea. The sludge that cannot be discharged, are kept in the sludge tank in order to be discharged at the port facilities.

- Closed type scrubber

This type uses fresh water instead which is treated with an alkaline chemical such as caustic soda neutralization for scrubbing. The wash water re-circulates the system and only a small amount after an additional treatment is discharged into the sea. The type of system can also include an extra tank in order to have zero discharges to the sea for a certain period.

8.2.3 Duel fuel engines

Duel fuel engine or pure LNG engines usually appear to be the best solution in order to fulfill the emission expectations and that is due to the following reasons:

- Natural gas / LNG is often defined as "clean fuel"
- NOx and CO_2 emissions are clearly lower than for Diesel engines
- Typically no SOx emissions
- very low particulate matter

A bonus benefit of the LNG fuel is that it does not require any kind of treatment in case of a spill. As it has lower density than sea water it floats on the surface of the sea until it is completely evaporated into the atmosphere.

LNG seems to be the future fuel of shipping but to speak the truth certain matters need to be overcome:

- HC/CH_4/CO emission must be minimized
- Valve timing and overlap optimization
- Flame quenching minimization

One of its major disadvantages is the great amount of energy that is used to liquefy the gas in order to transport it overseas and that poses the matter if the LNG is in fact a "dirty" gas.

Efficiency is also one of the key futures in the reduction of the emission of CO_2 from international shipping. Operational efficiency measures from IMO, like EEDI and SEEMP entered into force on 1 January 2013.

9 Avoiding accidents-casualties

In Ancient Rome, there was a period during which navigation was permitted and lasted, only from 27 May to 14 September. Certain calendars were even more restrictive, providing for a period of only fifty days starting at the summer equinox. (RODIERE, 1976)

The very first regulations concerning the ship's draught appeared in Venice in 1255. Ships were marked with a cross that indicated the maximum **load line**. (BOISSON, 1999) The following years the application of that technique was largely spread and became the most elaborated technique of the 14th century.

One of the fundamentals of today's regulations can be found in the very beginning of 15th century with conducted **surveys** by authorities to prevent accidents due to poor adequacy condition. Rules that enhance captain's power and responsibility were developed and also preventive rules were applied during the 16th century.

Continuous efforts for legislation and practices' development where transacted the following years but great changes were about to happen in the 19th century. The industrial revolution allowed the ship to become bigger and faster. Steam engines were now propelling the ship and iron replaced the wood in hull construction. Despite the **technological developments** the number of incidents was intensively high.

The range of sea travels was increased and ships started to operate way far from the shore. Lack of experience, on the new type of vessels, was commonly the reason for major accidents.

In 19th century, we have the first regulation on navigation systems. Until then no ship carried **navigation lights** except warships at night and when two ships where converged custom signs with the flag or a flare were performed to show one's presence. France and Britain signed an agreement about lighting of steamships in 1848. It was not an international convention but immediately copied from the other maritime leading nations. (I.LORANCHET, 1953)

Great Britain and France subsequently signed agreements that formed their legislation for collision avoidance. This trend of internationalization of legislation didn't come out of the blue, but reflected the long-time need for uniformity of ship regulations.

9.1 Human Factor

Conducted risk analysis point out the fact, that human error is the most common reason for an accident. Safety equipment and procedures are scheduled in a way that a single human error could not result major accident. Almost all systems include the human factor due to the fact that the operator gives usually the last command and can also override the prescheduled procedures. A system is characterized as safe, not only when it is efficiently functioning in normal operation, but also when it provides resilience and stability under tough conditions.

Thanks to technological advances machineries are able to have a more operator-friendly interface but complicated software information should never compromise the benefit of simplicity. In addition, a consolidation of different parameters concerning the same procedure is favorable approach compared to numerous indicators located in different places in the control area.

Humans and more precisely mariners have to possess two basic tools in order to successfully fulfill tasks and those are mental and physical condition.

One aspect of favorable *mental* condition is adequate **knowledge** concerning the required task. Understanding of all parts of the procedure such as "what are the actions to be made" and "what is the result of every action" contributes to a desirable outcome. Good handling of a single task shall not be limited to normal operation conditions but also during an unstable phase. **Awareness** of the key factors that contributes to the main functions of a procedure may result in an early detection of a deficiency and consequently to an accident prevention. Sufficient knowledge and good **seamanship** should be combined to achieve best results.

Working at sea has a requirement of long absence from shore during sea travels. Isolation and distance from friends and family may cause a form of depression. Having a negative **psychological condition** is a deficiency of major importance that can lead to personal injury or even a greater accident. Feeling depressed often drives to low working performance and lack of attention that may result to mistakes and high fatigue levels. Being an active member on recreational activities with the rest of the crew as well as sharing a problem or situation with coworkers may have a positive result.

Anxiety is another condition commonly seen among seafarers. It may occur in combination with the causes that results in depression and is usually enhance from the from the demanding working hour program. The ability to handle anxiety and work under pressure must be among the skills of a seafarer in order to be able to have favorable performance even in difficult situations.

Physical condition of the operator is another important variable that influence safety matters. Due to the nature of work mariners may have to perform individually a significant amount of tasks. **Healthy habits** like a good diet and proper rest are considered to be fundamentals concerning this subject. A seafarer should keep himself in good condition to be able to cope with the burden of work and also even deal more effectively with changing environmental conditions. Moreover a healthy person gets sick much more difficult and can deal with illnesses way more effectively.

The difference of a land-job between the work-onboard is that the worker lives in the working area and therefore, a clear separation of working and resting hours should be made. ILO has recognized that fact and for that reason has clearly defined how the work schedule should be formed for the marine industry. According to ILO statements eight hours of work should be performed in normal conditions during a day. Taking into account the special needs of the marine industry a maximum of 14 hours per day as well as 72 hours in a period of seven days has been issued. Conducted studies have shown that excessive long working hours reduce productivity and reduce the safety level of labor making workers more vulnerable to threats. Adequate resting hours are of equal importance and according to ILO a minimum of 10 hours during a day or 77 hour in a seven-day period. That is the theoretical approach that governs the marine labor but indeed most of the time Masters can suspend the working schedule to cope with demanding procedures. Those extra hours should be taken into account for every seafarer and each individual should be able to have compensatory resting hours in order to recover. The above-mentioned criteria are thoroughly described into the 2010 amendments to the STCW Convention and Code. (ITF, 2013).

9.1.1 Ergonomic Criteria

Ergonomics as described from the International Ergonomics Association is "The scientific discipline concerned with the understanding of interactions among humans and other elements of a system and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance." (ABS, "Guidance Notes On Ergonomic Design Of Navigation Bridges" , 2003)

Ergonomic criteria bound to harmonize the human presence inside a system. During the construction and installation of equipment handled by humans certain subject should primarily be into consideration in order to achieve the most favorable performance. In order to fit human entity inside the "Ship system" and have a desirable interaction, design should be governed by the following principals.

- An ergonomic design should take into account the characteristics of its user. Design **with respect on human capabilities** and limitations, is essential for the system's performance and safety.
- Machines are designed to handle in most of the cases an enormous amount of data and perform long calculations. The display of outputs should not include the complexity of the internal procedures. **Readable and understandable outputs** that do not require tough decoding, will allow smoother interaction and more direct feedback.
- In order to handle the amount of information coming out of a machine **standardize display** characteristics like a use of color coding may implement in a machine or a group of machines.
- Human attention can be easily be disturbed by different actions that are taking place in the same area. **Proper arrangement** of the working space as well as prioritize of indicators and actions to be made, can enhance mitigation of disturbing effects and human error.

With technological innovations systems become more and more powerful, able to perform more complex duties faster and more precise. The elation of technology shall not compromised glory of simplicity. A good design is not defined only by its capabilities. It has to be simple, direct, with barriers to and aids to limit human error. Human mistakes result to labor accidents, collisions, groundings which are sometimes escorted by vessel's foundering and possibly injuries or death. Reducing human error on board as well as settle a proper decision making ashore is a key element for maritime safety.

9.2 Fire

Fire on board is another top highlighted unpleasant condition which has been thorouhgly analyzed in order to permit a direct and effective way of mitigation. It is well known that it's way easier to deal with fire within the first seconds of its appearance than some minutes later. Fire and smoke detectors automatically raise the alarm in order to warn for a potential threat. If the threat is not combated by fixed firefighting systems further engagement of the crew may be required. Comprehensive knowledge of mechanism of fire and well-rounded understanding of firefighting equipment are enhancing the possibility to avoid the transformation of a small incident to a major disaster.

Fire is classified in five different types of categories for better understanding and coping with a fire incident. Specialized equipment is used for each type of fire in order to enhance safety and effectiveness.

Type A is the type of fire that most people are familiar. Fire fed by paper, wood or fabric is listed in this category A. Water type equipment is used against this type of fire like the water type extinguishers. This method is called "cooling".

Type B is related to flammable liquids like petroleum and derivatives, paints, etc. CO_2 and foam extinguishers are used in this case through "cooling" and "smothering" process.

Type C involves fires related to gases for ex. LNG, LPG, Acetylene. Dry chemical powder is used to put off this type of fire using the relative extinguisher. This process is called "inhibition".

Types D are fires involving flammable metals. Special dry DCP extinguishers are used to cope with these kinds of fires.

Type E is the last category, including fires due to electric current. Moreover in this category DCP can be used on firefighting operations.

9.2.1 Fire plan

Fire Control Plan is a very important document of a ship and it is also mandatory according to SOLAS described in Regulation 15 of Chapter II. It's a detailed guide which includes information about fire stations, escape routes, fire alarm systems and sprinkler installation. In addition it shows the ventilation system details for remote operation of dampers and fans. Every fire detection and firefighting equipment is roundly described in the fire plan.

Fire plan must be easy accessible in case of an emergency and therefore is must be permanently exhibit in various locations such as prestigious navigating bridge, engine room and accommodation.

Office of the company in shore must have at least one copy of the fire plan as well as one copy should be located marked watertight outside deckhouse. In case of a fire incident, happening in port or in dry-dock, a specialized team from shore will only need the details written in the fire plan to deal with this effectively.

As it can be easily assumed the fire plan must be renewed or updated as soon as any alteration may occur. Modifications in ship's structure, firefighting system, alarm system, escape route design or anything that may affect the current fire plan must be added to the new one. Approval from the classification society is required for the fresh plan. During Flag or classification society shift the fire plan must be review.

9.2.2 Firefighting equipment

A fire incident can be caused by many reasons and each reason may need a different type of confrontation method. Thereafter, a variety of firefighting equipment is used to ensure that every space within the vessel is ready to cope with this dangerous event.

9.2.2.1 Fire extinguishers

Five alternative types of a fire extinguisher are merely used on vessels each one specialized in different fire source. The weight of the portable firefighting equipment is usually less than 23 kg.

Water Type

Figure 40 Water Type extinguishers

This type of extinguishers is marked always with red color and they are located mainly at the accommodation spaces. A tube of approximately 60grams of CO_2 inside the extinguisher is enough to provide sufficient pressure (around 10bars) to expel the contained water out of the equipment with adequate force to fight a small fire. The duration time is around 60sec depending from the installed gas within.

Foam Type

The mainly have the same characteristics with the water type extinguishers. In addition, they contain a small amount (approx. 0.3 liters of AFFF). Their tube is marked with cream color and they are usually located in the engine room and the galley.

Figure 41 Foam Type extinguishers

Dry Chemical Powder Type

The material used to put off fire is NaHCO3. The duration time is less than half a minute and in order to quickly separate them from the other extinguishers they are marked with the blue color. Due to the fact that powder can easily destroy expensive furniture and equipment chemical powder are used merely in the engine room and galleys and not in the accommodation.

Figure 42 DCP extinguisher

CO_2 Type Fire

Like the previous type it lasts only about 0.2 minute providing carbon dioxide to fight fire. The pressure inside it is around 10 bars. The black color is used to signify that the extinguisher is a CO_2 type. Engine room, bridge and galley are equipped with this type of equipment.

Figure 43 CO_2 extinguisher

Wet chemical extinguishers find application at the galley were oils and fats from food can set a fire. They contain a wet chemical agent known as potassium acetate. Coping with fire is made by breaking the chain reaction between oil and fire

Figure 44 Wet chemical extinguisher

9.2.2.2 Water systems

Water is widely used onboard and it has an unlimited provision since it can be drained from the sea and find usage on the firefighting operations. Water has the best **absorption of heat** among all the other firefighting systems due to its good conductivity and the high rate of latent heat that absorbs in order to become steam. Water can be used as a strait stream as well as in fog form.

Straight streams

With this type of system a solid beam can be aimed to the fire. In order to achieve the best result the beam must be **aimed directly to the main core of fire** in order absorb as much heat as possible and reduce the temperature. Sometimes that may not be achievable due to obstacles or other factors (ex. excessive temperatures that restrict fire-team to get close to the fire). In that case an excessive waste of water will occur hence, only a small amount of water will contribute while the rest will be flushed away. This system has good reach and accuracy in an open area, but its effectiveness is reduced when it does not aim the seat of the fire.

Fog streams

Those systems also use the water distribution system of the vessel but with the use of a special nozzle the water flow breaks into small droplets. With that manner, larger areas can be covered and the absorption of heat is very effective. Fog stream systems have no good aiming abilities, but they don't have to hit the core of the fire in order to be effective. If we make a comparison with the previous system fog streams have limited range but using the same amount of water the heat absorption is greater and thus the waste is less. The tiny droplets can easily turn into steam because of the heat. The generated steam has approximately 1600 times greater displacement, than its previous form and can displace the air that supplies oxygen to the fire.

9.2.2.3 Foam systems

Foam is consisted from water, air and a foam making agent. Foam which is produced from such systems can be used effectively against "Type B" fires. Using foam, a blanket is formed on the top of a flammable liquid and by this manner oxygen and fuels are separated from one another. Fire cannot exist if those two elements are separated. In addition, water in the foam provides a desirable cooling effect. There are mechanical and chemical foams.

The complex role of foam, being the barrier between fuel and oxygen requires some specific characteristics. A **proper concentration** of the foam agent must be applied to create the desirable foam. The common factors are 3% and 6% foams. The foam must be **able to slip** on the surface of the liquid but **coherent** enough in order to create a tight barrier and not break. **Heat resistance** is a crucial ability that foam must have in order to cope with excessive heat generated from fire. Foam systems find application also on the deck of chemical and product tankers. The foam must be **light enough** to float on a liquid surface but still **heavy enough** to resist wind forces. Because the foam-blanket is placed directly on a flammable liquid intrusion of combustible compounds into the foam must be blocked by means of proper composition. Furthermore, the vapors of the liquid must be trapped above the surface of the foam and separated from the oxygen. If all the parameters are satisfied foam can be a very useful and effective ally against fire incidents.

Nevertheless, foam is consisted basically from water and thus there is a problem when the situation includes electricity. In case of "type E" fires as well as an electric device is operating in the near area foam must not be used. Foam is specialized on "Type B" fires but is not effective with C and D type of fires. Adequate amount of foam must be provided in order to successfully cover the surface of the liquid. If the barrier for any reason has been breached the effectiveness of the foam is compromised.

9.2.2.4 CO_2 systems

The CO_2 firefighting system is a total flooding system and in order to be effective a sufficient quantity must be provided in order to reduce the oxygen level in the applied area. CO_2 is colorless and odorless so it is not easily detectable. In addition, it's heavier than air so in case of a release or a leakage CO_2 will cover the nether levels of a room. Even in small proportion lower than 10% CO_2 can leave a person unconscious leaving trapped in a dangerous environment or causing asphyxia due to lack of oxygen. (ABS, "Guidance Notes On Fire-Fighting Systems", 2005)

The benefits of using gas systems for firefighting is that they have zero impact to electronics or other sensitive devices and the cleaning process after application is performed in less time comparing to other firefighting equipment (ex. use of water). In addition if the right proportion is applied in every kind of fire concerning class A, B, and C can be effectively detained. One of the major disadvantages of gas systems is the fact that some of them can be extremely hazardous to personnel. CO_2 even in small quantities has the effect of losing consciousness within a short time limit. That can lead to life threating consequences while a fire incident takes place as well in case of accidental system activation. Comparing a CO_2 system with a conventional waterborne system, it is noticeable a clear disadvantage concerning the cooling effect of the gas. CO_2 has a cooling ability, but it is so meager when compared to the cooling effect of water. In order to avoid high temperatures that can cause additional damage the CO_2 is designed for fast deployment and thus quick evacuation of the area that the incident unfolds, is a mandatory. The quantity of CO_2 is limited and it is carried in cylinders inside a secured space.

Such system is merely applied in the E.R or in cargo holds which "type B" and "type A" fires usually occur. The effectiveness of the system depends on

- how well the system functions (level of maintainance, proper amount of CO_2)
- How fast it is deployed (time of evacuation, crew training)

Last but not least proper usage of the system is necessary to achieve great results. CO_2 systems are not applied on "class D" or any material that can supply fire with oxygen through chain reactions. The use of CO_2 requires a closed space in order to be effective. Unsealed spaces or damaged compartments may not retain enough gas to detain fire.

9.2.3 Fireproof divisions

In order to cope with fire a passive protection in combination with active firefighting operation is required. Some of ship's bulkheads and decks are constructed to deal effectively with fire unlike ordinary designs.

- **"A" Class Divisions**

"A" Class Divisions type, decks or bulkhead are built with approved nonflammable materials and provide a sufficient barrier for fire or smoke. They also provide thermal insulation so in case of a fire on the one side of the barriers in the opposite side temperature will not rise more than 180°C above the ambient temperature. Different types of "A" class subdivisions provide equivalent time lap protection. By means an "A-60" class provides adequate resistance for 60 minutes. There are also "A-30", "A-15", and "A-0" providing the prescribed type of protection for the equivalent time. The letter "A" refers to the category of the class division and the number indicates the equivalent time in minutes that prerequisites about insulation are fulfilled.

- **"B" Class Divisions**

"B" Class Divisions are decks, bulkhead or linings built with approved non-combustible materials that can provide fire and thermal insulation up to half an hour. "B" class divisions are tested on a fire test and can ensure that no points of the unexposed side of the division will rise above 225°C of the original temperature.

- **"C" Class Divisions**

"C" Class Divisions are bulkheads, decks, ceilings and linings constructed of approved non-combustible materials. Those divisions have no requirements relative to the passage of smoke and flame neither limit of temperature rise.

The construction of all doors on a "A" Class divisions for example must, as far as practicable, provide at least the same level of security against smoke, fire and temperature insulation.

9.2.4 Subdivision into zones

With respect to the area's explosive atmosphere onboard, there are three types of zones that describe the potentiality of fire hazard. [19]

- **Zone 0**

In this type of area most likely an incident will take place. An explosive atmosphere is permanently present or exists most of the time. Areas characterized as zone 0 are mainly insides of tanks and pipes carrying flammable substances with flash point smaller than 60°C. Equipment used inside those areas must be specially certificated and cables located in the mentioned areas should be properly protected (covered, reinforced, running through metal tubes)

- **Zone 1**

In those sections air/gas mixtures or vapors or dust, usually present, incites the possibility of fire or explosion. These are less hazardous areas compare to those marked as zone 0 but still enough dangerous for application of special requirements. Areas characterized as zone 1 are given in Table 21.

Table 20 Potential *zone 1* areas

1.	open deck
2.	semi-enclosed spaces on open deck
3.	Closed cargo spaces
4.	closed or open Ro-Ro cargo spaces
5.	Stationary containers
6.	Within 3m of cargo tank ventilation outlets

As in zone 0 areas, equipment used in those specific spaces must be certificated with the ability to work safely in flammable environments. According to rules publication of DNV-GL that came into force on January 2016, non-safe equipment in zone 1 must be switched off and "safeguarded against unauthorized re-switching". Portable electrical equipment should also be certificated to minimize potential threats.

- **Zone 2**

Zones characterized as "type 2" are areas which can be separated by gas-tight doors from hazardous areas. Also areas within two meters beyond the "zone 1" are to be considered as zone 2. Moreover, type 2 areas are mechanically ventilated with at least 6 changes of air per hour.

9.2.5 Inert gas system

Nowadays IGS has a large implementation on vessels. Inert gases are usually noble gases like Argon and Helium because of their non-reactive properties. Nitrogen plants can be also used for the neutralization process. Different uses of the inert gas system make it indispensable for everyday operations. Placing a neutral coat of inert gas above a flammable cargo is one of the most common uses of IGS but in certain cases such as in Gas Carriers, protective barriers between tanks and the ship's hull are filled with inert gas to reduce hazards in case of a leakage. In all cases it is always beneficial to fill the surrounding spaces of a tank that contains flammable cargo so in case of a rupture dangerous gases will escape to a secured ambient. To avoid corrosion inside places (e.g. cofferdams, voids, holds) IGS can be used to dry the tanks. Due to the hazards that occur when flammable vapors are released to the atmosphere IGS must be used prior to the gas freeing procedure. The neutralization process is also required before the loading condition in order to achieve a safe environment for the cargo load.

9.2.5.1 Inert gas composition

The composition of inert gases cut down chemical reaction like hydrolysis oxidation and other reactions with the surrounding air thus they contribute both safety and maintenance. Attention should be given in case of IGS implementation on NH_3-Carriers. Inert gas applied on that specific cargo should not contain carbon dioxide thus dangerous formations of carbamides may occur. Carbamate formations are used commonly for pesticide and fungicides. Infection through skin contact, respiratory and digestive system can lead to fatal error of vital organs in both animals and humans. (Gupta, Dwivedi, Gupta, & Parmar, 1974)

9.2.5.2 Inert gas production

Carriage of flammable cargos requires the presence of inert gas protection. Nitrogen generators or inert gas combustion generators may be used onboard. Storage tanks can be used to stock nitrogen supplied from the terminal in lack of inert gas plants.

A common combustion generator's formation includes: a scrubber, a combustion chamber and a sea cooling water system.

The **combustion chamber** can be the main engine or an individual chamber. After combustion, the percentage of oxygen is 5% or less (proportion unable to fire/explosion ignition even if there is an ignition source).

The exhaust gas of the chamber passes through a **scrubber** where it's sprayed with sea water. With this process, the hot gases are cooled and most of the sulfur dioxide is removed. A scrubber continues to operate a least one hour after the inert gas operation in order to remove as much corrosive substances as possible. A **demister** is used to remove as much water as possible.

Air distillation

Another process that can provide inert gases is air distillation. Atmospheric air contains a variety of gases and also water vapor that differs in different altitude and location. Air also contains suspended dust, spores, and bacteria. (Shakhashiri, 2007) The composition of dry air is showed in figure below.

Composition of Dry Air

Substance	% by volume
Nitrogen, N_2	78.08
Oxygen, O_2	20.95
Argon, Ar	0.93
Carbon dioxide, CO_2	0.033
Neon, Ne	0.0018
Helium, He	0.00052
Methane, CH_4	0.0002
Krypton, Kr	0.00011
Nitrogen(I) oxide, N_2O	0.00005
Hydrogen, H_2	0.00005
Xenon, Xe	0.0000087
Ozone, O_3	0.000001

Figure 45 Composition of dry air

Nitrogen like many of the other substances of air is obtained through air distillation. Dry air is compressed and thus the temperature of the air mixture is rising. Radiators are used to cool the compressed air. When the compressed cooled air is allowed to expand rapidly the temperature falls in such level that part of it condenses. Through an iterative process, most of the air can be liquefied. Different boiling points of the composing parts of the air allow the distillation process to take place. Production of nitrogen at -196°C is one of the most common procedures in the chemical industry.

IG system onboard

A number of safety systems and alarms are installed to ensure high-quality IG. Oxygen, temperature and pressure analyzers are fit to indicate if the IG properties are in the correct level. A vent that leads to the atmosphere or a recirculation line is installed before the deck main distribution line in order to ensure high quality inert gas. The main line delivers IG to secondary lines that lead to every tank. A non-return valve ensures that gases from tanks won't access the engine room space. The deck seal is a secondary barrier that prevents gases from backflow. All tanks are equipped with relief valves and electronic pressure sensors. The main line is also connected to the P/V breaker and the Must Riser to cope with both under or over-pressurization. P/V breaker like the deck seal is always operational to prevent tanks from failure.

The most important use of IGS is during discharge. If the system fails, the cargo handling operations should be canceled until the system works properly and all subsystems are stable. Once the discharge procedure is finished the pressure should be kept at least 100mmWG and the oxygen level at 5% or lower.

Gas freeing

In order for a person or a group of persons to enter a cargo space some specific procedures should take place in order to ensure the correct ambient. The air should contain 21% of oxygen and less than 1% of flammable substances. Oxygen is checked by sensors located in different levels of the tanks. Dangerous gases as well as inert gases should be removed to allow inspection activities.

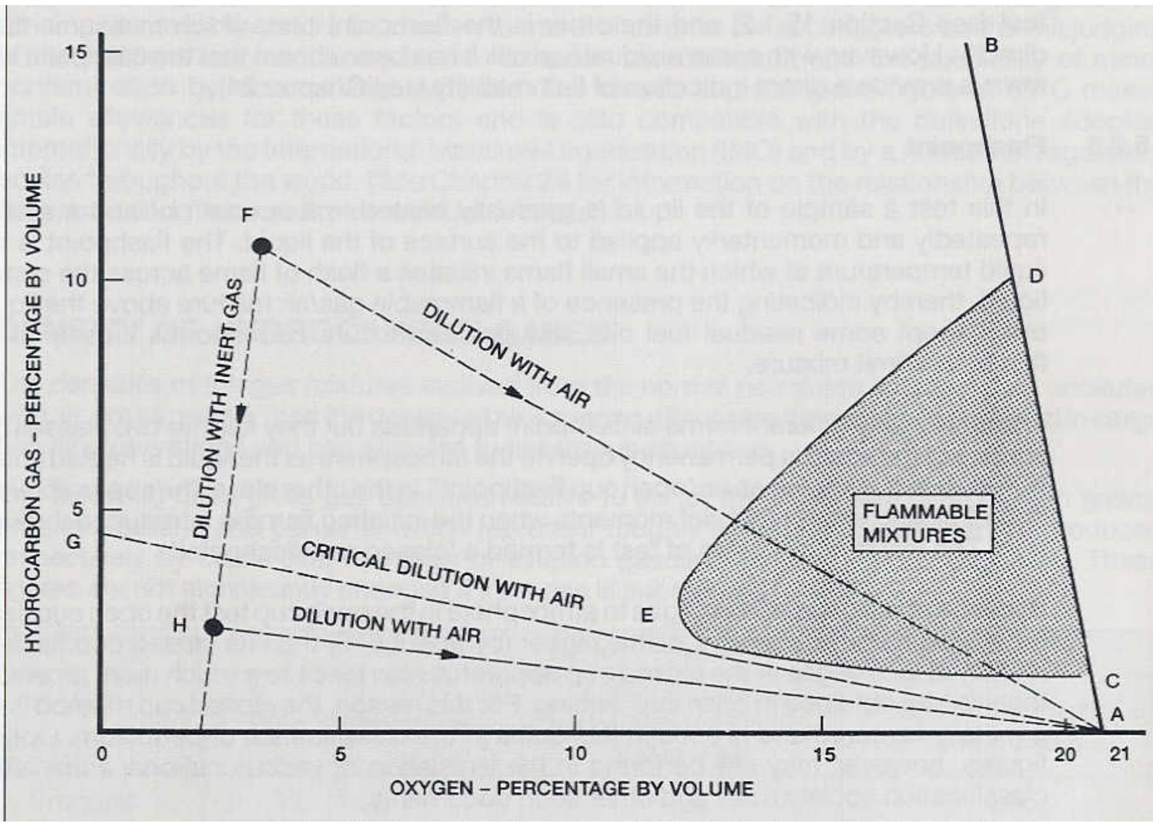


Figure 46 Hydrocarbon mixtures effect on flammability

According to the Figure 45, there is only a specified area with flammable mixtures. In other cases the mixture is too rich or too poor (with respect to the contained hydrocarbons) and thus a fire could not take place. If the mixture is rich of hydrocarbons and the gas freeing process is performed, the mixture will cross the flammable area through the process and with every presence of ignition source, a fire/explosion will take place. In order to avoid that kind of danger the purging procedure is taking place before the gas freeing of the tank. When the hydrocarbons level is below 2% the gas freeing process can begin. The gas freeing continuous until the required air properties are fulfilled but further measurement should be made before tank entering. Checking also for H_2S content or farther measurement according to the MSDS may be needed.

For entering a tank the Master's permission must be given and the full procedure should be supervised by a senior officer. The exact procedures can be found in the Ship's manual and also in ISGOTT Annex I. Only persons directly involved with the gas freeing process should be on the main deck. All participants should wear protective equipment and antistatic clothes to avoid sparks. The ambient should be constantly monitored until the end of the operation. When all persons come out, the tank should be re-inerted.

Gas freeing as well as Cow is not permitted when the ship is at the terminal, unless a special approval has been given from shore. Hidden dangers in gas freeing process are incidents like gases released in the atmosphere, in certain conditions, can enter the accommodation space or re-fill the tank. Wind's measurements and course adjustment can be performed to minimize this thread otherwise positive pressure restricts gases' entrance.

9.3 Lifesaving equipment

9.3.1 Lifeboats

Figure 47 Closed type lifeboats

If all the alternatives are exhausted and the ship is no longer in safe condition for the people onboard, an evacuation process to a safer area may be performed through lifeboats. After a verbal announcement from the captain, the evacuation may begin and everybody should gather to the muster stations. The count of the crew is necessary prior to embarkation and in the meantime water and food supply as well as blankets should be gathered. Removing the safety pins and engaging the brake lever will automatically release the davit of the lifeboat. In many cases the boat must be lowered to the embarkation deck. A quick check with respect on the navigation systems, engine condition, and drain plug must be performed by the engineer and deck officer. The lifeboat must be able to lunch from davits with trim angles up to 10° and heeling angles up to 20°.

There are merely two kinds of **release mechanisms** used onboard:

- *Off load release mechanism* requires the boat to be lowered to the sea level and automatically the release mechanism disconnect the boat from the hook if in any case the mechanism fails, a crew member can detach manually the hook.
- When the *on load release mechanism* is used, the lifeboat does not require to reach the sea surface. Usually, the release happens 1m above sea level and thus the impact is not brutal to threat the integrity of the boat or the crew inside. A lever inside the boat allows operating the

release mechanism from inside. That provide an additional safety barrier in case of dangerous conditions around the boat (ex. fire) with respect to the fact that no crew member has to go outside the boat to manually release the lifeboat like "off-load release mechanism" requires.

- "Free fall" lifeboat uses an on-load release mechanism but does not require lowering the boat near the sea level. The boat is launched directly from the embarkation level providing the quickest way for the evacuation process. An interior lever releases the boat from the davit.

Lifeboat drills are essential onboard to ensure that everybody is familiar with the process and will take the proper actions as scheduled in case of an emergency. However, boat-drills reported many injuries or deaths of crew members during training.

9.3.2 Liferafts

Figure 48 Liferafts

Liferafts are an alternative choice instead of lifeboats, usually used on passenger and cruise ships. Their advantage is that they are easy to deploy. However, equipment in them is more limited as compared to a lifeboat. This type of saving equipment inflates itself automatically as soon as it touches the water with a non-toxic gas provided by an attached bottle (e.x. CO_2) There are mainly four types of liferafts such as Davit-Launched, Self-Righting, Open Reversible and Throw-Overboard. The cases that the liferafts are included are equipped with a mechanism called Hydrostatic Release Unit (HRU). After they submerge into the water a hydrostatic lock, brakes when the hydrostatic pressure reaches the threshold value and releases the liferaft to the surface. In that manner even when the lifesaving equipment sinks with the ship, liferafts will immerge to the surface.

9.3.3 Personal equipment

9.3.3.1 Lifebuoys

Figure 49 Lifebuoy

According to SOLAS, 1974 at least 1 buoy at each side will be provided with a floating cable and at least half of the buoys will be provided with automatic lights by means that they automatically start to function when they touch the water. Buoys' characteristics are thoroughly described in Chapter III of SOLAS and their required number as per occasion is indicated in Table 22. (IMO, "INTERNATIONAL LIFE-SAVING APPLIANCE ",(LSA code),SOLAS, 1996)

Table 21 Required lifebuoys according to SOLAS

Length of ship(m)	Minimum required lifebuoys
<60	8
60 to 120	12
120-180	18
180-240	24
>240	30

9.3.3.2 Life-jackets

Figure 50 Life-jacket

At least one life-jacket for each person onboard must be available as well as an additional 10% for children. Jackets must be easy to use and should be constructed to fulfill all the requirements that SOLAS indicates. They are also equipped with a whistle to allow localization in rescue operations.

9.3.3.3 Suits

There are merely three types of suits that found application on vessels. Their use is focused on keeping the user warm or dry or both in order to cope with difficult conditions.

Immerge suit

An immersion suit is fabricated with such way that can provide enough buoyancy without the use of a life-jacket. The materials which the suit is designed, should provide enough insulation and according to SOLAS requirements, "for a period of 1h in calm circulating water at a temperature of 5°C, the wearer's body core temperature does not fall more than 2°C". In addition, some suits are designed in such way that a life-jacket can be worn above the suit. The design of the suit must be comfortable by means that a person should be able to perform basic tasks in an evacuation procedure.

Thermal suits

A thermal suit is fabricated with water-resistance materials in order to be effective even in a rainy environment. Furthermore, low thermal conductivity (less than 0.25 W/(m.K)) isolate the heat radiated from the human body (user) and in this way, the person stays warm until the rescue operation is over. Like similar equipment, thermal suits take an approval in order to be used onboard. A thermal suit is able to cover the whole body except from the face, even if a person wears a life-jacket.

Anti-exposure suits

The anti-exposure suit is used merely to help the wearer while he is exposed to bad weather conditions like wind, rain and cold. Additionally, it has an inherent buoyancy of "at least 70 N" according to SOLAS. Constructed with waterproof materials the anti-exposure suits must also have a fire resistance of at least 2 seconds in order to reduce the danger of combustion of the entire uniform in fire-evacuation conditions.

The most common protective equipment used onboard is listed in Table 23.

Table 22 Protective equipment used onboard

Helmet	The most important part of the body is the head. A singe hit can lead to severe injure or even death. It is essential to wear a helmet to avoid crossing or falling objects. Helmets usually contain a chin stripe to secure that the gear will stay on and protect the head regardless the conditions.
Goggles/glass	Eyes are the most sensitive part of the human body and eye injuries are very common if the correct gear is not used. Appropriate eye protection equipment secures the eyes from flying objects sparks or even splashed liquids.
Safety Shoes	Special working shoes with steel reinforcement protect the foot from injuries. Sophisticated designs include antistatic and anti-slip materials.
Safety Hand gloves	Gloves, depending on use, differ from toxic to heat and electric resistance type. Each type ensures the maximum protection for each different task.
Protective Clothing	Well known also as the boiler suit this equipment put a barrier for also most the hall body.
Ear plug	Noise can be as much harmful as annoying. Exposure to level noise of 110-120db commonly appears in the engine room can lead to partial or permanent hearing loss.
Safety harness	Due to the huge dimensions of the ship, crew may need to perform (e.g. maintenance operations) in high elevated places and thus a protective gear is used to prevent falls.
Chemical suit	Chemicals are substances that are usually very aggressive with skin contact and also other materials. Chemical suits are built to cope with this trouble and ensure that chemicals properties will not cause a problem.
Face mask	Respiratory system is the most common way for someone to get intoxicated or inhale dangerous particles included in the air. Face masks are used to filter the incoming air before it enters the human body.
Welding shield	Welding mask protect the eyes in welding operations. Direct sparks are blocked and a special glass filters the harmful UV radiation.

In case of one or more protective system's failure, an emergency evacuation must be applicable. The evacuation procedure must be well-defined and understood from all members.

If an incident occurs, the first action is raising the alarm. No person should enter a space to attempt rescue unless additional help comes and PPE such as breathing apparatus, is used. The only case that the breathing apparatus can be skipped is when the cause of the accident is clearly not related with the ambient air.

The minimum items for rescue operations are the following ones:

- EEBD

Figure 51 Emergency escape breathing device

The emergency escape breathing device is a supplied-air or oxygen apparatus that is used to escape from a deficient ambient to an area of safety. They must have a minimum operation time of 10min and they are usually fabricated for 10 to 20 minutes operation time. EEBDs are not to be used in firefighting applications or entering deficient tanks or voids. Their location must be indicated on the ship's fire plan. EEBD must stay properly maintained and also spare parts must be available on the ship's store.

According to SOLAS regulations a minimum number of EEBDs must be located in the accommodation spaces as showed in Table 24.

Table 23 SOLAS requirements EEBD

EEBD minimum requirements		
Ship's Type	**Number of EEBDs**	**Number of spares**
Cargo Vessel	two (2) EEBDs	one (1) spare EEBD
Passenger ships (carrying not more than 36 passengers)	two (2) EEBDs for each main vertical zone	two (2) spare EEBDs
Passenger ships (carrying more than 36 passengers)	four (4) EEBDs for each main vertical zone	

- Resuscitator

This device is designed to manually provide medical oxygen as required by the medical first aid guide.

Figure 52 Resuscitator

- Life line and Harness

Figure 53 Life line

Figure 54 Harness

Lifelines and harness should be available at the entrance of an enclosed space. Falls are more common while working on heights and can lead to serious injuries or death. Therefore, using the appropriate safety equipment is a necessity to avoid unpleasant situations.

- SCBA

Figure 55 Self-contained breathing apparatus

Self Contained Breathing Apparatus (SCBA) is used in Fire Fighter Outfit. The full face mask covers the air gates and also protects the eyes from irritating gases and heat. The capacity of air bottle should be at least 1200 liters and a sound notification must alert the user when the remaining quantity has reached above 20%. The total weight of the equipment must not exceed the value of 19kg.

Continuous communication should take place between the rescue team and the supervisor and also the captain must be aware of the progress.

9.4 Vaccination

Concerning some of the most common diseases found on seafarers working environment, vaccination processes have been established to avoid contamination. A list with the diseases and their vaccines are indicated below according to the Danish maritime Authority:

Yellow Fever is a viral disease, which is transmitted by mosquitoes. Common symptoms are sudden fever, shivers, headache, muscle pain, nausea and vomiting. At a later stage, jaundice can possibly occur but also the disease can take place without any signs of symptoms. Vaccination for yellow fever is available and is effective from ten days after vaccination and for ten years seafarers that will visit risk areas like Africa and South America must hold a valid, international certificate of vaccination.

Cholera is a water and food borne bacterial infection. Risky areas for such disease are Asia, Africa and South America. However, outbreaks are usually in synergy with natural disasters. Symptoms from this disease can be life-threatening due to the excessive loss of fluids. Prevention for Cholera should be primarily, proper ways of boiling or cleaning water and eating food that is thoroughly done. Shellfish food constitutes a great thread. Vaccination is available, however it protects partially seafarers, preserving only against the common "tourist diarrhoea". A drinkable vaccination is disposable but it is no longer mandatory as international requirement. Certain countries still require cholera vaccinations thus it's better for seafarers to be vaccinated prior boarding on ship to avoid onboard vaccination when visiting such areas.

Hepatitis A can be transmitted due to poor hygiene conditions and contaminated drinking water. It is found worldwide but mostly in Northern Europe and North America. Common symptoms are fever, stomach aches, nausea and jaundice which are usually developed after 3 weeks. Proper hygiene manners are a good way for prevention. Vaccination is also at disposal in two doses and after the second one a seafarer is protected for at least 20 years.

Hepatitis B is a sexual transmitted disease that can be transferred also when the person gets in contact with infected blood. This disease can be found worldwide most notably in Asia, Africa and South America. The symptoms from the infection may vary from no symptoms to excessive fever, nausea, stomach ache as well as skin disorders of yellow skin and white eyes. Avoiding contact with other's people blood or fluids as well as shun treatment with no sterilized instruments is a good way to avoid infection. Vaccination is available and after three doses a person is considered protected for 10 years.

Japanese encephalitis is a viral disease, which is also transmitted by mosquitoes. Reported symptoms are headache fever and weakened consciousness. This disease is only located is Asia and merely in poor regions especially during rainy weather. Prevention from mosquito bites notably during sails along rivers is a good technique since the disease is only transmitted through mosquito bites and not among humans.

Typhoid fever is another bacterial infection disease that only affects humans. This disease can be found worldwide and someone can be affected through food and water where hygiene conditions are poor. Symptoms are usually developed after 10 to 20 days with headaches coughing and constipation followed by two weeks of excessive fever, drowsiness and diarrhoea. Avoiding no well-heated food and precautionary vaccination can effectively protect from getting infected. Available vaccines are effective after 2-3 weeks and last for three years.

Tuberculosis is an airborne bacterial infection that is found worldwide. As an airborne disease it is transmitted through coughing and sneezing more efficiently in closed spaces. Common symptoms are: fever, night sweats loss weight and coughing. Avoiding contamination can be possible when a person who coughs uses a hanky or mask and also avoid contact with coworkers in closed rooms. There is also a vaccine but it is only recommended prior traveling to high risk areas for long periods. This vaccine is valid after six weeks and last up to 10 years.

Polio can be transferred through contaminated water but also between humans through cough and sneeze. It is still found in countries like Pakistan and India and as well in certain regions of Africa. Illness can be progress with no symptoms but in case of a respiratory system infection, serious symptoms such meningitis, paralysis or even death may occur. Vaccine for Polio is available from the young age and after vaccination the person is protected for a life time.

Diphtheria and tetanus are both diseases caused by bacteria. In most countries vaccination for contamination prevention is included in children vaccination program. However, a revaccination is recommended every 10 years. (DMA, 2007)

9.5 Drills

In order to ensure good awareness and experience for a dangerous situation that possibly will appear on a vessel, periodical drills are programed for the crew. Drill is an exercise that is planned to maintain all members of the ship sharp and ready for difficult situations. Common drills applicable on merchant vessels are listed in Table 25.

Table 24 Drills aboard

Drills Onboard	
Drill	**Description**
1. Abandon Ship	Abandoning the ship is a situation that no one wants to be involved but when it happens it must be performed in a best way in order to avoid additional casualties and minimize the threat of human loses. Abandoning the ship is signed by seven short and one long blast and all crew and passengers shall gather to the master stations. In order to abandon the ship a verbal order must be given from the captain. After that, lifeboat loading can start. SOLAS requirement indicates at least one drill per month, for crew members. In addition a drill shall take place within 24h of ship departure if the 25 percent of the crew have not experienced an abandon ship procedure in the previous month.
2. Blackout	The main purpose for blackout training is to get familiar with the possible system's failure and the low light condition. According to SOLAS regulations, the emergency generator will automatically start within 45 seconds so the key of success in similar situation is to keep calm, identify the source of the malfunction and avoid panic.
3. Oil/ Chemical Spills	In a time with great ecological concern it is essential that in case of a spill immediate actions will minimize the damage. Drills related to this subject ensure reduction of damage caused by a leak and avoidance of additional hazards (e.x fire)
4. Emergency Steering Drill	Emergency steering gear drill is to be conducted at least once in three months. All ship officers engaged with the steering gear shall know how to operate and change from one system to another.

5.	*Man Overboard Drill*	The man overboard drill is performed on the vessel in order to ensure that in case of a real incident the crew member or passenger can be recovered onboard. A full simulation should take place including launching of the Man Over Board marker and performing rescue turns. Namely the "Q-turn" (quick-turn) is used but also the "Anderson turn", the "Williamson turn", and the "Scharnow turn" are performed upon occasion.
6.	*Fire*	Fires are a major source of upcoming hazards. Like the drill of the abandon ship every crew member should experience a drill at least once in a month and also in case that 25 percent of the crew has not experienced a fire drill the past month, the drill should take place within 24h of ship's departure. In addition according to SOLAS "When a ship enters service for the first time, after modification of a major character or when a new crew is engaged, these drills shall be held before sailing". A fake case scenario drill with all the equipment is also performed to measure the crew's capability.
7.	*Flooding*	Flooding can threat the life of the crew members as well as the ship's integrity. In occasion like that, each crew member has an assigned duty that must be perfectly executed to achieve the best results. Drills help that everyone will respond properly in a real incident.
8.	*davit-launched liferafts*	Those drills shall be performed at least once every four months and according to SOLAS a special liferaft for training purpose only may be used.
9.	*Rescue boats*	Rescue boats must be launched at least once every three months with its assigned operating crew aboard and manoeuvred in the water.
10.	*free-fall lifeboat*	According to SOLAS (Regulation 19 3.3.4) "Lowering into the water, rather than launching of a lifeboat arranged for free-fall launching, is acceptable where free-fall launching is impracticable provided the lifeboat is free-fall launched with its assigned operating crew aboard and manoeuvred in the water at least once every six months"
11.	*Enclosed spaces*	As it is already mentioned, enclosed spaces can lead to great hazards. Thus information and rotational training course must be conducted in order to ensure a brief understanding of hazards and clear all doubts.
12.	*Watertight doors*	Operation and inspection of watertight doors shall take place once a week according to SOLAS (Chapter II-1,regulation 24)

Regardless the fact that drills *enhance protection* and s*afety of people* onboard, *ship's integrity*, and *environmental health*, they are not warmly welcome from the ship's members as they are considered to be additional tasks added to the overall work. Some reasons may lay also to the overconfidence to the ship facilities or personnel's skills.

10 Conclusions –Results

As it can be clearly seen ship transportations are highly monitored and regulated in order to enhance health and safety. Despite the numerous surveys and regulations, accidents continue to occur revealing uncovered deficiencies of existing processes or new ones due to recent developments and innovative applications. An accident can be characterized as a successful event due to the fact that a great number of security mechanisms were been bridged in order for an accident to happen. **Recording and analyze accidents** is essential so that similar situations will be avoided in the future.

It is well known that major requirements and regulations have been adopted after big disasters. **Rational investigation** of the origins of the accident as well as the transitional period is a necessity for the resulting legislation to be effective. Many complains have been reported through the years accusing the applied measures to be just additional paper work and cost instead of safety precaution oriented. **Continuous monitoring of progress and revising the legislation** are vital components for the future of the maritime industry.

As it is easy for someone to realize safety procedures and protective mechanisms may require additional time to fulfill a task comparing to unsafe manners. Safety comes with a price and therefore bypassing safety procedure, may need less time but increases the possibility of an error that will definitely has unfavorable results. Not using the correct procedures according to ISM put in danger the operator and also may affect everyone onboard. There may be a ranking division between the crew members but no one's life is less important than the other's and thus **shortcuts on safety procedures are not an option** for anyone.

Primary malfunctions or mistakes occur prior to a bigger accident. **Early detection** and fast reaction may reduce the effects or even avoid a larger scale deficiency. Any mistakes or faults must be reported as soon as possible to senior officers in order to prevent a chained reaction that make put in danger the life of the crew members or the integrity of the ship. **Good communication** between senior officer and the company representatives in shore must be achieved to ensure that safety has not been compromised.

Risk assessment is round and continuous process including the following steps.

- Assess the process
- Identify hazards included in the procedure
- Apply measurements and precautions
- Reassess the whole process

If the applied measures are not properly performed existing or additional risks will instantly reduce the safety level. Moreover, insurance companies deeply investigate the conditions which an incident took plays therefore any deficiency on safety measurements may question the eligibility for compensation.

The ship's hull accommodates numerous of components. To comprehend as well as to install all the equipment in an optimal way is a real challenge for designer. **Ergonomic criteria** should be taken into consideration during the installation process. A critical factor that must not be forgotten during the installation of the outfitting is that the majority of the components may, at least once in the life time of the ship, needed to be maintained or upgraded or even replaced by another one. Safety manners require a consideration in order to approach, inspect, maintain or replace the equipment in a safe way.

Team work and good seamanship is the secret recipe for good and safe travels. Onboard people from different cultures and beliefs must achieve a good level of teamwork as well as correctly perform individual tasks. Respect and dignity between co-workers will enable a smooth and effective working environment.

11 Subjects into consideration

Shipping is a fascinating and interactive environment that makes a great contribution to our word. Safety mechanisms must be applied and regularly developed in order to minimize any harmful impact that shipping may cause. Every person engaged with the shipping industry shall be responsible and feel culpable of the impact that may have.

Future challenges of shipping

- **Fuel**

It is obvious, that drain of reachable oil reservoirs of the earth, incites the need of an alternative fuel other than heavy fuel oil.

- **Type of cargo**

Oil tankers have a large percentage of the transporting deadweight. The question lies to the question of which will be the future cargo to be carried out that can provide economically sustainable sea transports.

- **Environmental awareness**

New and stricter rules considering environmental protection are constantly introduced and assimilate to the sea transport legislation.

- **Hard competition**

More and more people were engaged to ship transport and the ship's supply significantly increased. Therefore, all competitors should provide their most quality services in order to survive. Aviation developments may succeed to provide sustainable transportation taking a good cut from the cargo vessels.

- **Terminals capacity**

In order to benefit from the economy of scale and be able to provide competitive freights, ships tend to enlarge in sizes prohibited for certain ports. In order to achieve good handling of massive amounts of cargo, high automation may be the key. Terminals will also need to deal with the fact that bigger ships may be followed by lower frequency services more intensive peaks of work.

- **New designs and materials**

Merely, all the rules that have been introduced until this day had written based on the knowledge, obtained from the previous experience. Existing legislation and safety techniques may not fit with future innovations.

Despite the many challenges and problems in ship transportations, strong foundations and a mindset governed by adaptability and flexibility can sail over every obstacle. Like Ella Wheeler Wilcox said "One ship drives east and the other drives west by the same winds that blow. It's the set of the sails and not the gales that determines the way they go."

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13 Appendix

Table 25 Flammable range of gases

Fuel Gas	"Lower Explosive or Flammable Limit"(LEL/LFL) (% by volume of air)	"Upper Explosive or Flammable Limit"(UEL/UFL) (% by volume of air)
Acetaldehyde	4	60
Acetic acid	4	19,9
Acetone	2,6	12,8
Acetyl chloride	7,3	19
Acetylene	2,5	81
Acrolein	2,8	31
Acrylonitrile	3	17
Allyl chloride	2,9	11,1
Ammonia	15	28
Arsine	5,1	78
Benzene	1,35	6,65
1,3-Butadiene	2	12
n-Butane	1,86	8,41
iso-Butane	1,8	8,44
iso-Butene	1,8	9
Butyl acetate	1	8
Butyl alcohol, Butanol	1	11
Butylene	1,98	9,65
Butyl methyl ketone	1	8
Carbon Disulfide	1,3	50
Carbon Monoxide	12	75
Cyanogen	6	42,6
Cyclobutane	1,8	11,1
Cyclohexane	1,3	8
Cyclohexanol	1	9
Cyclopropane	2,4	10,4
Cyclohexanone	1	9
Dekane	0,8	5,4
Diborane	0,8	88
1,1-Dichloroethane	6	11
Diethyl Ether	1,9	36
Diesel fuel	0,6	7,5
Diethanolamine	2	13
Diethylamine	2	13
Diethylether	1,9	48
Dimethyl sulphoxide	3	42
Diisobutyl ketone	1	6
Diisopropyl ether	1	21
Epichlorohydrin	4	21
Ethane	3	12,4
Ethylene	2,75	28,6
Ethyl Alcohol, Ethanol	3,3	19
Ethyl acetate	2	12
Ethylamine	3,5	14
Ethylbenzene	1	7,1
Ethyl Chloride	3,8	15,4
Etylene glycol	3	22
Ethylene oxide	3	100
Fuel Oil No.1	0,7	5
Furan	2	14

Furfural	2	19
Gasoline	1,4	7,6
Glycerol	3	19
Heptane	1	6,7
Hexane	1,1	7,5
Hydrogen	4	75
Hydrogen sulfide	4,3	46
Isobutane	1,8	9,6
Isobutyl alcohol	2	11
Isophorone	1	4
Isopropyl Alcohol, Isopropanol	2	12
Kerosene Jet A-1	0,7	5
Methane	5	15
Methyl Acetate	3	16
Methyl Alcohol, Methanol	6,7	36
Methyl Chloride	10,7	17,4
Methyl Ethyl Ketone	1,8	10
Mineral spirits	0,7	6,5
Naphthalene	0,9	5,9
n-Heptane	1	6
n-Hexane	1,25	7
n-Pentene	1,65	7,7
Naphtalene	0,9	5,9
Neopentane	1,38	7,22
Neohexane	1,19	7,58
Nitrobenzene	2	9
Nitromethane	7,3	22,2
n-Octane	1	7
iso-Octane	0,79	5,94
n-Pentane	1,4	7,8
iso-Pentane	1,32	9,16
Propane	2,1	10,1
Propyl acetate	2	8
Propylene	2	11,1
Propylene oxide	2,3	36
Pyridine	2	12
Silane	1,5	98
Styrene	1,1	6,1
Tetrahydrofuran	2	12
Toluene	1,27	6,75
Trichloroethylene	13	90
Triptane	1,08	6,69
Turpentine	0,8	
Vinyl acetate	2,6	13,4
Vinyl chloride	3,6	33
p-Xylene	1	6

Table 26 Auto-ignition temperature

Fuel or Chemical	Auto-ignition Temperature	
	(°C)	(°F)
Acetaldehyde	175	347
Acetic acid	427	801
Acetone, propanone	465	869
Acetylene	305	581
Anthracite - glow point	600	1112
Benzene	560	1040
Bituminous coal - glow point	454	850
Butane	405	761
Butyl acetate	421	790
Butyl alcohol	345	653
Butyl methyl ketone	423	793
Carbon	700	1292
Carbon disulfide, CS_2	90	194
Carbon monoxide	609	1128
Charcoal	349	660
Coal-tar oil	580	1076
Coke	700	1292
Cyclohexane	245	473
Cyclohexanol	300	572
Cyclohexanone	420	788
Dichloromethane	600	1112
Diethylamine	312	594
Diethylether	160	320
Diethanolamine	662	1224
Diesel, Jet A-1	210	410
Diisobutyl ketone	396	745
Diisopropyl ether	443	829
Dimethyl sulphoxide	215	419
Dodecane, dihexyl	203	397
Epichlorohydrin	416	781
Ethane	515	959
Ethylene. ethene	490	914
Ethyl acetate	410	770
Ethyl Alcohol, Ethanol	365	689
Fuel Oil No.1	210	410
Fuel Oil No.2	256	494
Fuel Oil No.4	262	505
Furfural	316	601
Heavy hydrocarbons	750	1382
Heptane	204	399
Hexane	223	433
Hexadecane, cetane	202	396
Hydrogen	500	932
Gas oil	336	637
Gasoline, Petrol	246 -280	475 - 536
Glycerol	370	698
Gun Cotton	221	430
Kerosene	295	563
Isobutane	462	864
Isobutene	465	869
Isobutyl alcohol	426	799
Isooctane	447	837
Isopentane	420	788
Isopropyl alcohol	399	750
Isophorone	460	860
Isohexane	264	507
Isononane	227	440
Isopropyl Alcohol	399	750
Light gas	600	1112
Light hydrocarbons	650	1202
Lignite - glow point	526	979
Magnesium	473	883
Methane (Natural Gas)	580	1076
Methanol, Methyl Alcohol	470	878
Methyl acetate	455	851
Methyl ethyl ketone	516	961
Naphtha	225	437
Neohexane	425	797
Neopentane	450	842
Nitrobenzene	482	900
Nitro-glycerine	254	490
n-Butane	405	761
n-Heptane	215	419
n-Hexane	225	437
n-Octane	220	428
n-Pentane	260	500
n-Pentene	298	569
Oak Wood - dry	482	900
Paper	218 - 246	424 - 475
Peat	227	440
Petroleum	400	752
Pine Wood - dry	427	800
Phosphorus, amorphous	260	500
Phosphorus, transparent	49	120
Phosphorus, white	34	93
Production gas	750	1382
Propane	470	878
Propyl acetate	450	842
Propylene, propene	458	856
Pyridine	482	900
p-Xylene	530	986
Rifle Powder	288	550
Triethylborane	-20	-4
Toluene	535	995
Semi anthracite coal	400	752
Semi bituminous coal - glow point	527	980
Silane	< 21	< 70
Styrene	490	914
Sulphur	243	470
Tetrahydrofuran	321	610
Toluene	530	986
Trichloroethylene	420	788
Wood	300	572
Xylene	463	867

Table 27 Member states of IMO

Members of IMO 2016	
Albania	1993
Palau	2011
Zambia	2014
Algeria	1963
Angola	1977
Antigua and Barbuda	1986
Argentina	1953
Australia	1952
Austria	1975
Azerbaijan	1995
Bahamas	1976
Bahrain	1976
Bangladesh	1976
Barbados	1970
Belgium	1951
Belize	1990
Benin	1980
Bolivia (Plurinational State of)	1987
Bosnia and Herzegovina	1993
Brazil	1963
Brunei Darussalam	1984
Bulgaria	1960
Cabo Verde	1976
Cambodia	1961
Cameroon	1961
Canada	1948
Chile	1972
China	1973
Colombia	1974
Comoros	2001
Congo	1975
Cook Islands	2008
Costa Rica	1981
Côte d'Ivoire	1960
Croatia	1992
Cuba	1966
Cyprus	1973
Czech Republic	1993
Democratic People's Republic of Korea	1986
Democratic Republic of the Congo	1973
Denmark	1959
Djibouti	1979
Dominica	1979
Dominican Republic	1953
Ecuador	1956
Egypt	1958
El Salvador	1981
Equatorial Guinea	1972
Eritrea	1993
Estonia	1992
Ethiopia	1975
Fiji	1983
Finland	1959
France	1952
Gabon	1976
Gambia	1979
Georgia	1993
Germany	1959
Ghana	1959
Greece	1958
Grenada	1998
Guatemala	1983
Guinea	1975
Guinea-Bissau	1977
Guyana	1980
Haiti	1953
Honduras	1954
Hungary	1970
Iceland	1960
India	1959
Indonesia	1961
Iran (Islamic Republic of)	1958
Iraq	1973
Ireland	1951
Israel	1952
Italy	1957
Jamaica	1976
Japan	1958
Jordan	1973
Kazakhstan	1994
Kenya	1973
Kiribati	2003
Kuwait	1960
Latvia	1993
Lebanon	1966
Liberia	1959
Libya	1970
Lithuania	1995
Luxembourg	1991
Madagascar	1961
Malawi	1989
Malaysia	1971
Maldives	1967
Malta	1966
Marshall Islands	1998
Mauritania	1961
Mauritius	1978
Mexico	1954
Monaco	1989
Mongolia	1996
Montenegro	2006
Morocco	1962
Mozambique	1979
Myanmar	1951
Namibia	1994
Nepal	1979
Netherlands	1949
New Zealand	1960
Nicaragua	1982
Nigeria	1962
Norway	1958
Oman	1974
Pakistan	1958
Panama	1958
Papua New Guinea	1976
Paraguay	1993
Peru	1968
Philippines	1964
Poland	1960
Portugal	1976
Qatar	1977
Republic of Korea	1962
Republic of Moldova	2001
Romania	1965
Russian Federation	1958
Saint Kitts and Nevis	2001
Saint Lucia	1980
Saint Vincent and the Grenadines	1981
Samoa	1996
San Marino	2002
Sao Tome and Principe	1990
Saudi Arabia	1969
Senegal	1960
Serbia	2000
Seychelles	1978
Sierra Leone	1973
Singapore	1966
Slovakia	1993
Slovenia	1993

Solomon Islands	1988
Somalia	1978
South Africa	1995
Spain	1962
Sri Lanka	1972
Sudan	1974
Suriname	1976
Sweden	1959
Switzerland	1955
Syrian Arab Republic	1963
Thailand	1973
The former Yugoslav Republic of Macedonia	1993
Timor-Leste	2005

Togo	1983
Tonga	2000
Trinidad and Tobago	1965
Tunisia	1963
Turkey	1958
Turkmenistan	1993
Tuvalu	2004
Uganda	2009
Ukraine	1994
United Arab Emirates	1980
United Kingdom of Great Britain and Northern Ireland	1949
United Republic of	1974

Tanzania	
United States of America	1950
Uruguay	1968
Vanuatu	1986
Venezuela (Bolivarian Republic of)	1975
Viet Nam	1984
Yemen	1979
Zimbabwe	2005
Total number of IMO States 2016	**171**

Table 28 International Conventions IMO

	International Convention	**Date of Adoption from IMO**	**Entered into force**
1.	*Facilitation of International Maritime Traffic(FAL)*	9 April 1965	5 March 1967
2.	*Convention on Load Lines (LL)*	5 April 1966	21 July 1968
3.	*Tonnage Measurement of Ships*	23 June 1969	18 July 1982
4.	*Intervention on the High Seas in Cases of Oil Pollution Casualties (INTERVENTION)*	29 November 1969	6 May 1975
5.	*Civil Liability for Oil Pollution Damage (CLC)*	29 November 1969	9 June 1975
6.	*Special Trade Passenger Ships Agreement (STP)*	6 October 1971	2 January 1974
7.	*Civil Liability in the Field of Maritime Carriage of Nuclear Material*	17 December 1971	15 July 1975
8.	*Regulations for Preventing Collisions at Sea (COLREGS)*	20 October 1972	15 July 1977
9.	*Prevention of Marine Pollution by Dumping of Wastes and Other Matter*	13 November 1972	30 August 1975
10.	*Convention for Safe Containers (CSC)*	2 December 1972	6 September 1977
11.	*Prevention of Pollution from Ships (Marpol)*	2 November 1973	2 October 1983
12.	*Safety of Life at Sea (SOLAS)*	1 November 1974	25 May 1980
13.	*(Athens)Carriage of Passengers and their Luggage by Sea (PAL)*	13 December 1974	28 April 1987
14.	*International Maritime Satellite Organization (IMSO)*	3 September 1976	16 July 1979
15.	*(Torremolinos)Safety of Fishing Vessels (SFV)*	2 April 1977	
16.	*Standards of Training, Certification and Watchkeeping for Seafarers (STCW)*	7 July 1978	28 April 1984
17.	*Maritime Search and Rescue (SAR)*	27 April 1979	22 June 1985
18.	*Suppression of Unlawful Acts Against the Safety of Maritime Navigation (SUA)*	10 March 1988	1 March 1992
19.	*Convention on Salvage*	28 April 1989	14 July 1996
20.	*Oil Pollution Preparedness, Response and Co-operation (OPRC)*	30 November 1990	13 May 1995
21.	*Standards of Training, Certification and Watchkeeping for Fishing Vessel Personnel (STCW-F)*	7 July 1995	29 September 2012
22.	*Liability and Compensation for Damage in Connection with the Carriage of Hazardous and Noxious Substances by Sea (HNS)*	3 May 1996	Not yet
23.	*Civil Liability for Bunker Oil Pollution Damage (BUNKER)*	23 March 2001	21 November 2008
24.	*Control of Harmful Anti-fouling Systems on Ships*	5 October 2001	17 September 2008
25.	*Control and Management of Ships' Ballast Water and Sediments (BWM)*	13 February 2004	Not yet
26.	*(Nairobi) Removal of Wrecks*	18 May, 2007	14 April 2015
27.	*Safe and Environmentally Sound Recycling of Ships(Hong Kong)*	15 May 2009	Not yet

*Protocols and amendment have been issued to modernize or supersede the adopted conventions

13.1 Ship accidents gallery

Figure 56 “Nagato Reefer”, 9 April 2014 lifeboat fails during ship inspection, Southampton, UK.

Figure 57 “Stellamare” heavy lift carrier, 3 people killed on Dec. 9, 2003 Port of Albany, N.Y. (ship with 289 feet long with a 50.9ft beam.)

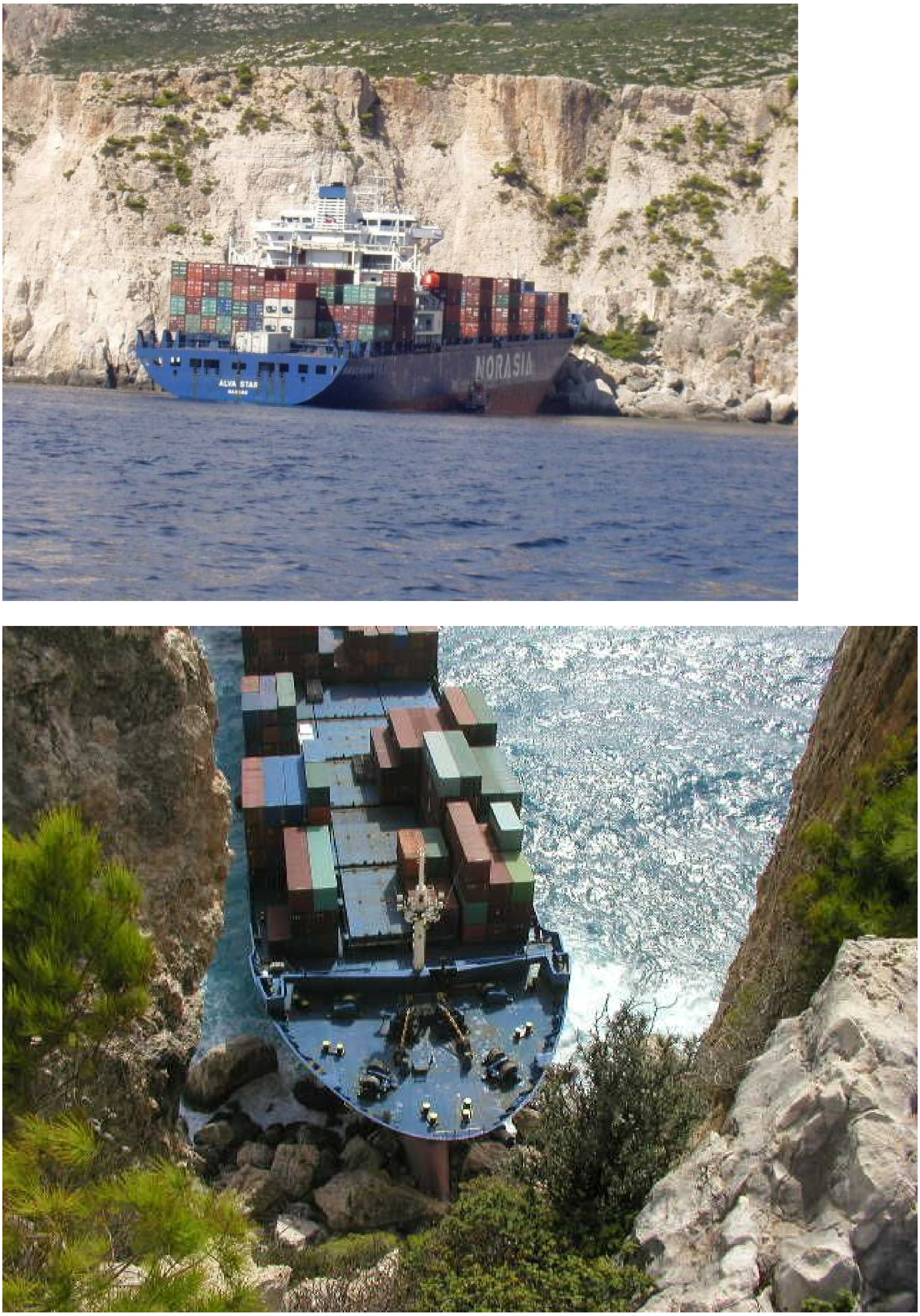

Figure 58 “Alva Star”, Container ship grounding (3rd of October, the "Alva Star", 235.7m, 41.570 dwt Vs=22knots Zakynthos Greece)

Figure 59 3 January 2015, “Hoegh Osaka” car Carrier, Solent Stait Northern England

Figure 60 August 2014 “Diver Master”, tug boat, Esbjerg, Denmark