Environmental liability in business management – Ballast Water Management Systems

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Abstract

From this position I would like to thank the Professor of the Department of Shipping Trade and Transport of the University of Aegean, Mr Ioannis Theotokas, who helped me to decide which one with be the issue of my dissertation and guided me in finding information and writing the dissertation.

Finally I have to thank all those who helped in the civil service and private companies I visited in order to collect data for my study.

This paper was prepared during the period February 2018- September 2018, under the supervision of the Professor of the Department of Shipping Trade and Transport, Ioannis Theotokas.

The main subject of this dissertation is the study and the exploration of how the Shipping Industry includes the Environmental liability in her business management and at the same time how the new Regulations of Ballast Water Management Systems are treated by Shipping.

Environment is the basis of life and economic activities that enable the development and prosperity. The importance of water for humans, both from economical and social view, is proved by the fact that the majority of the world’s population lives in coastal areas. Coastal ecosystems are the most susceptible, as land and water area are in constant interaction and functional interdependence.

An important part of the oil transportation system by sea, is the caused pollution which is generated in the event of an accident. The phenomenon of an oil spill causes social outrage if it happens. The environment itself bears considerable since the failure of oil to be mixed with water creates many problems in the marine and coastal flora and fauna.

Furthermore, an oil spill impacts negatively on economic, social and political life of the region that suffers. All these have led to continued efforts to reduce the influence from everywhere.

The spectacular marine accidents that result in pollution are those that historically have monopolized the media attention, but it is not clear that long-term damage to the marine environment due more to them and no other causes that occur almost daily on a regular basis, but spend usually unnoticed.

The study carried out and presented in detail in this dissertation was intended to "touch" this sensitive and very important issue of accidental oil pollution from tankers in order to draw meaningful conclusions and to find out how the Shipping Industry confronts with this issue, and also to deepen at “Ballast Water Management System” issue, which is so important up to date.
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INTRODUCTION

Scientists believe that life at the oceans started 3.6 billion years ago. It is pretty obvious that, the size and the composition since then; and also the organisms that live at the seas; changed and their revolution goes on. Covering more than 70 percent of our planet, oceans are among the earth’s most valuable natural resources. They govern the weather, clean the air, help feed the world, and provide a living for millions. They also are home to most of the life on earth, from microscopic algae to the blue whale, the largest animal on the planet. Yet we’re bombarding them with pollution. By their very nature—with all streams flowing to rivers, all rivers leading to the sea—the oceans are the end point for so much of the pollution we produce on land, however far from the coasts we may be. And from dangerous carbon emissions to choking plastic to leaking oil to constant noise, the types of ocean pollution humans generate are vast. As a result, collectively, our impact on the seas is degrading their health at an alarming rate.

Traditionally, it has appeared that the shipping industry and port sector have pursued their own independent agendas in terms of achieving compliance with legislation and the priority given to the various environmental issues. However, with the current trends towards environmental management of the port area and the logistic chain, greater collaboration between the various players is recognized as being a practicable and cost-effective option of ‘swim together or sink together’.

The environmental imperative itself has broadened significantly in context from the initial focus on habitats and species to the current debate on global climate change and the development of structures and organizations necessary to deliver environmental protection and sustainable development. With the ubiquitous nature of shipping at a global scale and the significance of ports to their cities and hinterlands, both these marine operations are key players in the strategic development and implementation of appropriate environmental management systems.

Indeed, the constituent companies that make up the diverse mix of maritime interests are under pressure to identify and publish the environmental performance indicators by which they claim to confirm compliance with environmental legislation, demonstrate continual improvement of environmental quality, and track the effectiveness of the management system itself. Science-based evidence that will satisfy an environmental audit or stand scrutiny in a court of law is essential if the industry’s benchmark performance and claimed attainment of standards are to be accepted as credible.

The potential hazards of shipment and handling of oil, the problems posed by ballast water, the effect of TBT, and the impacts of dredging are all potentially newsworthy items in the event of an incident as well as being part of daily operations for the industry itself. Yet, consideration of the physical processes alone can be a sterile focus in terms of understanding and significance. More is gained by studying the science in conjunction with the functional organization necessary to control the impacts of marine operations. Successful environmental management requires science-based criteria on which to base decision-making if
environmental protection and sustainable development is to be attained in the complex and potentially hazardous regime of the working port area.

CHAPTER 1

1.1 MARINE POLLUTION

How much oceans mean for life at our planet is proved by the fact that plankton and algae are more important at the primary production of O2 by keeping CO2, than forests do. Also, it should be mentioned that most ecosystems depend on the oceans, because they control climate systems, water and gas cycles, on which life in land is based.

For this reason, it wouldn’t be an overstatement to say that life started from the oceans, and its quality is closely related to them. The last centuries, human activities are seriously threaten the seas by pollution, overfishing, submarine excavations, and chemical /thermal ocean deterioration, which have a bad effect on the planet.

1.1.1 Definitions

**DEFINITION OF MARINE POLLUTION BY GESAMP**

"Pollution means the introduction by man, directly or indirectly, of substances or energy into the marine environment (including estuaries) resulting in such deleterious effects as harm to living resources, hazards to human health, hindrance to marine activities including fishing, impairment of quality for use of sea water and reduction of amenities".

Under the **Greek Law 743/1977**, which is for the Protection of Marine Environment, **marine pollution** is defined as

“The introduction by man, directly or indirectly, of substances or energy into the marine environment (included estuaries) which results in or is likely to result in such deleterious effects as harm to living resources and marine activities, including fishing and other legitimate uses of the sea, impairment of quality for use water an reduction amenities”

The sources of Marine Pollution are:

- Land Sources
- Atmosphere
- Shipping Activities
- Dumping
- Exploration and Exploitation of the sea bed

and are presented at the next diagram.

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1.1.1 Diagram Sources of Marine Pollution

Source: CSMP-IOC-UNEP, 2002

1.1.2 Oils

The sea burden from the worldwide trade of 1.5 billion tons of petroleum by 6000 Oil Tankers comprises an important source of marine pollution. Every year are recorded almost 25 major incidents, with the result of 700 tons of petroleum to be spilled at sea\(^\text{2}\).

1.1.2 Diagram Sources of Marine Pollution By Oils


\(^\text{2}\) ITOPF, 2002
1.1.3 Organic-Inorganic Compounds

The Persistent Organic Pollutants constitute a hazardous threat for the oceans. Those substances are very toxic and it is proved that at a least quantity they can cause mutations and carcinogenicity. They are not bio-decomposed, with the result of being accumulated in animal’s and plant’s tissues, threatens by this way the human being. At those substances are amongst organotin compounds which are contained at paints of ships, Polychlorinated Biphenyls (PCB), insecticides and in particular the DDT and its compounds. There has been noticed serious impacts on sea organisms during their exposure at those toxic substances, such as reproductive disorders and hormonal dysfunctions.

A toxic compound category which also causes carcinogenicity and intoxications are heavy metals. They are also being accumulated in animal’s and plant’s tissues, which raises concern about their dissemination through food chain.

1.1.3 Toxic compound pathways in aquatic systems

Source: USGS Science for changing the world, MAJOR FINDINGS

When we burn fossil fuels, we don’t pollute just the air but the oceans, too. Indeed, today’s seas absorb as much as a quarter of all man-made carbon emissions, which changes the pH of surface waters and leads to acidification. This problem is rapidly worsening—oceans are now acidifying faster than they have in some 300 million years. It’s estimated that by the end of this century, if we keep pace with our current emissions practices, the surface waters of the ocean could be nearly 150 percent more acidic than they are now.

1.1.4 Nutrients

Nutrient pollution comes from many sources and many sectors of the economy. Every year the spill of huge quantities of fertilizers, urban sewage, burning fossil fuels, from small boats,
to large cruise boats, transfer a huge amount of nitrogen and phosphorus at sea. And it's the excess of two primary nutrient causes the problems of hypoxia.

In the Baltic Sea, over 50% of the phosphorous comes from inadequate treatment of waste water or from poorly functioning household septic systems. We also have a growing problem with nitrogen which comes from agriculture. On average, about a quarter of it comes from large animal farms and a quarter of it comes from fertilizers. However, hypoxia increased tremendously after World War II, with an industrialization of agriculture and with the growing populations in coastal cities. Today, the hypoxic area is over 65,000 square kilometers. That's the size of the states of Maryland and Virginia put together. The consequences of hypoxia have profound social and economic impacts. Hypoxia causes phosphorous to be released from bottom sediments which comes up into the water column and enhances the growth of a type of algae called cyanobacteria, which are better known as blue-green algae, many of which are toxic. The second aspect of hypoxia is it's killing fish and reducing areas for spawning. So, we need to cut both nitrogen and phosphorous loads to the oceans. In the Baltic Sea, it has been developed an action plan to reduce nutrients that has been agreed upon by all nine countries surrounding the Baltic Sea.

1.1.5 Sewage

In many areas worldwide, industrial and urban raw sewage are split at the oceans, burden the marine environment with heavy metals, persistent organic pollutants, nitrogen and phosphorous nutrients, and microbes. The consequences to human health are really serious, causing worldwide 250 million cases of gastroenteritis, and ten thousands cases of typhoid, hepatitis A & B and cholera originating in swimming at contaminated waters or consumption of contaminated sea food.3

1.1.6 Dumping

The Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972, commonly called the "London Convention" or "LC '72" and also abbreviated as Marine Dumping, is an agreement to control pollution of the sea by dumping and to encourage regional agreements supplementary to the Convention. It covers the deliberate disposal at sea of wastes or other matter from vessels, aircraft, and platforms. It does not cover discharges from land-based sources such as pipes and outfalls, wastes generated incidental to normal operation of vessels, or placement of materials for purposes other than mere disposal, providing such disposal is not contrary to aims of the Convention. It entered into force in 1975. As of September 2016, there were 89 Parties to the Convention.

The 1996 Protocol represents a major change of approach to the question of how to regulate the use of the sea as a depository for waste materials in that, in essence, dumping is

3 Shuval H.I .,1986
prohibited, except for materials on an approved list. This contrasts with the 1972 Convention which permitted dumping of wastes at sea, except for those materials on a banned list.\textsuperscript{4}

In accordance with the article 3 of International Rules on Dumping waste at sea (London Dumping Convention 1972)- Protocol 1996 as “dumping” defined as:

“It bans or regulates the dumping of wastes depending on their danger to the environment. Among those whose dumping is banned (Annex I) are crude oil and petroleum products, mercury, cadmium, radioactive wastes, plastics and some others. Materials listed in Annex II require a special permit before they can be dumped. They include such substances as arsenic, lead, copper, fluoride, zinc, pesticides etc. The dumping of all other wastes requires a prior general permit issued on the authority of a Contracting Party. In recent years, regulations have been increasingly tightened. The dumping of all radioactive wastes has been banned, as has the dumping of industrial wastes and the incineration of wastes at sea”.\textsuperscript{5}

Dumping comes mainly from materials marina’s dredging, channel raster and navigable waterways, which are usually polluted. Also, radioactive and useless military equipment split at the oceans burdens like this the sea in various depths.\textsuperscript{6}

1.1.7 Bio’Pollution’

*Ballasting- De-ballasting

Every year, merchant shipping transports 150 million tons of ballast. For a VLCC (Very Large Crude Carrier) with a capacity of 160000-320000 DWT, the quantity of ballast that is transported is from 50000 up to 110000 tons DWT, while for a ULCC (Ultra Large Crude Carrier) with a capacity of 320000-550000 DWT, the ballast quantity turns to be 185000 tons. Organisms and microbes are released at the areas where the ship’s loading has been arranged, and if they reside there, it will probably be caused problems at the ecosystems of that area and, by extension, at human’s health.

*Fish Farm

Fish farming burdens marine environment with many and various ways. The sewage of the farmed fish, the foods and the substances which are contained to them (antibiotics), and the entry of new species in marine ecosystems are some main ways.

*Fishing- Overfishing

The management of worldwide fish stocks is a very complicating issue, but it is pretty obvious that without any measures for the exploitation and the restriction of marine pollution in a worldwide scale, any possibility for recovery of that scarce resource will be a failure with catastrophic consequences for the Fishing Industry.

\textsuperscript{4} IMO, International rules on dumping of wastes at sea to be strengthened with entry into force of 1996 Protocol
\textsuperscript{5} Focus on IMO, Preventing Marine Pollution, March 1998, (g) Dumping
\textsuperscript{6} OSPAR, 2003
1.1.8 Other threats

*Exploration and Exploitation of the sea bed

This threat is pretty serious, if one considers the fact, that the last 15 years almost 1000 production platforms have been constructed and have been active at worldwide marine era. In this situation, the pollution comes by leaks, incidents, and dismantling. The use of coastal area and the pressure that is exerted by humans at this sensitive area burdens the coastal ecosystems. The distraction of those ecosystems has a prompt impact in marine ecosystems, because ones conservation and development is closely bounded with the others quality.

*Climate Change

There is no doubt that the planet’s temperature is still rising. The greenhouse effect rapidly affects the temperature and the planet’s climate. Researches have shown that deep sea ecosystems response at the climate changes.

Diagram 1.1.4 UAH Satellite-Based Temperature of Global Lower Atmosphere

Source: CO2 vs Temperature, The Carbon Sense Coalition

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7 G. Vlachos, 2007, V. S. Tselentis, 2002

8 G. Vlachos, 2002

At the diagram is presented the global temperature anomaly as compared with the CO2 emissions, between 1960 and 2015. As we understand, during the years the global temperature and the CO2 emissions still rise.

Taking into account the data of United Nations Intergovernmental Panel for the Climate Change (IPCC), the following changes are estimated to be done at the oceans:

- Up to the end of 2100, the sea level will be raised 13 to 94 cm, flooding the coastal areas and destroying many of those coastal societies and industries.
- There will be a change at the currents, with the result of the biotopes to be changed.
- The average temperature at the global lower atmosphere will be raised by 1-3.5°C, as a result, the extinction of organisms that are affected by the change of temperature.
- The Ice of Poles will be melted, and a huge amount of sweet water will be entered at sea affecting salinity levels.

*Shipping Activities*

The pollution that is caused by shipping activities can be distinguished by two categories, one caused by accidents and the operational pollution.

*Accidental pollution* is the result of sudden events, independent of human will. It may, for example, occur following the rupture of a pipeline, a fire or a shipwrecking.¹⁰

*Operational pollution* as distinct from pollution which may occur when oil is released to the sea as the result of a casualty.¹¹

Diagram 1.1.5 Average annual inputs of oil into the sea from ships and other sea-based activities

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¹⁰ Sources of Pollution, Accidental Pollution
¹¹ Maybourn R., The Prevention of Oil Pollution, Operational pollution from tankers and other vessels
At Diagram 1.1.5 are presented the ways where oil pollution is approached, for finding out the importance of those sources and to analyze them. This procedure strengthens the quality of data and as a result it supports the rational management and solution of the problem.

**1.1.9 The principal pollutants from Ships**

At this section the principal pollutants that are produced in a vessel will be referred, as they are categorized by the International Convention MARPOL73/78. Oils, Gaseous Emissions, Wastes and Exhaust Emissions are those pollutants.

*Oils*

In accordance with the ANNEX I of the International Convention MARPOL73/78, as Oils are prescribed the following:

- Crude Oil
- Mazut
- Lubricating oils and blending stocks
  Excluding animal and vegetable oil

The Oil Wastes of a vessel are separated at the following categories:

- Used mineral oils
- Fuel remaining
- Residues
- Sludge
- Sewing Ballast
- Tank washings

*Wastes*

The Wastes from vessels in accordance with the ANNEX V of the International Convention MARPOL73/78, can be distinguished by two categories, domestic and operational wastes.

**Domestic Wastes**

- Food Wastes
- Packaging materials (plastic, bottles etc.)
- Hospital Wastes
- Bottles
- Paper

**Operational Wastes**

- Maintenance Wastes
- Packaging materials (paper, plastic, barrels etc.)
- Rust
- Ash
- Pallets
- Straps
The principal wastes that turn up at sea based on data of UNEP are the following:

**Land**
- Waste’s Transport by rivers
- Industries
- Tourism

**Sea**
- Merchant Vessels, Cruise Ships, Passenger Ships
- Fishing boats
- Yachts
- Research boats
- Naval Ships
- Fish Farms

*Gaseous emissions*

As it is mentioned at Diagram 1.1.1, the pollution that comes from international shipping transportation combines marine and atmospheric pollution. Until recently, this kind of pollution it was thought to be the only one that pollutes the oceans. When we burn fossil fuels, we don’t pollute just the air but the oceans, too. Indeed, today’s seas absorb as much as a quarter of all man-made carbon emissions, which changes the pH of surface waters and leads to acidification. This problem is rapidly worsening—oceans are now acidifying faster than they have in some 300 million years. It’s estimated that by the end of this century, if we keep pace with our current emissions practices, the surface waters of the ocean could be nearly 150 percent more acidic than they are now.

As we already know from the water cycle, it is inevitable to be polluted the marine environment, when there are many gaseous emissions. The atmospheric pollution comes basically from land (industries, transportation etc.), but also it is caused by shipping trade.

*Exhaust emissions*

The ingredients from vessels’ gas exhausts (diesel machine) are:

**Main Ingredients:**
- Nitrogen (N₂)
- Oxygen (O₂)
- Vapors
- Carbon Dioxide (CO₂)

**Secondary Ingredients:**
- Carbon Monoxide (CO)

---

- Sulphur Oxides (SOx)
- Nitrogen Oxides (NOx)
- Hydrocarbon
- Airborne Particles

At the following Table 1 there is a comparison of SOx and NOx Emissions from Land and Vessels.

**Table 1: NOx, SOx, VOC, CO₂ & PM Comparison, Years 2000, 2010, 2015 & 2020**

<table>
<thead>
<tr>
<th>Year</th>
<th>NOx</th>
<th>SO₂</th>
<th>VOC</th>
<th>CO₂</th>
<th>PM</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>2,810</td>
<td>1,949</td>
<td>99</td>
<td>120,644</td>
<td>235</td>
</tr>
<tr>
<td>2010</td>
<td>3,382</td>
<td>1,945</td>
<td>128</td>
<td>155,666</td>
<td>278</td>
</tr>
<tr>
<td>2015</td>
<td>3,710</td>
<td>2,212</td>
<td>145</td>
<td>177,046</td>
<td>317</td>
</tr>
<tr>
<td>2020</td>
<td>4,061</td>
<td>2,515</td>
<td>165</td>
<td>201,442</td>
<td>360</td>
</tr>
</tbody>
</table>

*Source: European Commission Directorate General Environment Service Contract on Ship Emissions: Assignment, Abatement and Market-based Instruments*

**Chapter 2:**

**MARPOL 73/78**

**2.1 Historical Review**

Although marine pollution has a long history, meaningful and effective international laws to counter it were only enacted during the twentieth century. Beginning in the 1950’s, marine pollution became a concern during the course of several United Nations Conferences regarding the Law of the sea. At that time, it was believed by most scientists that the oceans were so vast that they had unlimited ability to dilute, and thus render pollution harmless.

Marine pollution occurs when harmful, or potentially harmful, effects result from the entry into the ocean of chemicals, particles, industrial, agricultural and Residential waste, noise, or the spread of invasive organisms. The main types of pollution which are caused by ships specifically are Toxic waste, harmful substances carried in packages, sewage discharging, by the disposal of garbage, air pollution, noise pollution and last but not least oil pollution.

In order to address this harmful situation the International Convention for the prevention of pollution of the sea by oil, 1954, (OILPOL) was amended in 1962, the wreck of the Torrey Canyon in 1967 sparked controversy and resulted in a series of conventions and other
instruments, including further amendments to the 1954 Convention, which were adopted in 1969.

In 1971, the International Convention for the prevention of pollution of the sea by oil, 1954, (OILPOL) was amended again, however it was generally felt that an entirely new instrument was required to control pollution of the seas by ships. Finally, in 1973 IMO convened a major conference to discuss the whole problem of marine pollution by ships. It resulted in the adoption of the first ever comprehensive anti-pollution convention, the International Convention for the Prevention of Pollution from Ships and thus MARPOL was born. Its objective was to minimize pollution of the oceans and seas and preserve the marine environment.

In 1978, IMO convened a Conference on Tanker Safety and Pollution Prevention, which adopted a protocol to the 1973 MARPOL Convention introducing further and stricter measures which included requirements for certain operational techniques and a number of modified constructional requirements.

2.2 THE INTERNATIONAL CONVENTION FROM THE PREVENTION OF POLLUTION FROM SHIPS

The 1973 International Convention for the Prevention of Pollution from Ships needed ratification by 15 countries, with a combined merchant fleet of not less than 50 percent of world shipping by gross tonnage, and by 1976, it had only received three ratifications by Jordan, Kenya and Tunisia which represented less than one percent of the world's merchant shipping fleet. This was despite the fact that countries could join to the Convention by only ratifying Annexes I (oil) and II (chemicals). Annexes III to V, which cover harmful goods in packaged form, sewage and garbage, were optional.
It began to look as though the Convention might never enter into force, despite its major importance. In 1978, in response to the tanker accidents which took place between 1976-1977, IMO held a Conference on Tanker Safety and Pollution Prevention in February 1978. In February 1978, the Conference was attended by delegates from 61 countries, observers from 3 countries and representatives from 17 international organizations - a total of 451 people. The Conference adopted a protocol to the 1973 MARPOL Convention, absorbing the original Convention and amplifying the requirements for tankers in order to make them less likely to pollute the aquatic environment.

Additional measures were also incorporated into the 1978 Protocol to the International Convention for the Safety of Life at Sea (SOLAS), 1974 involving tanker safety. The measures included the demand for inert gas systems (through which exhaust gases, which are low in oxygen and thus incombustible, are used to replace flammable gases in tanks) on all new tankers over 20,000 dwt and specified existing tankers. Requirements for steering gear of tankers, rigorous requirements involving the radar and other collision avoidance aids, and stricter regimes for surveys and certification were also included in the SOLAS Protocol.

In pursuance of implementing MARPOL as swiftly as possible, the Conference allowed that the Parties would have 3 years to implement Annex II of the convention starting from the date of entry into force of the protocol, in order to get countries to accept Annex I.

The 1978 MARPOL Protocol and the SOLAS Protocols were viewed as gargantuan steps in raising construction and equipment standards for tankers through more severe regulations. The commitment to push through the legislation and make the regulations mandatory was made clear by a number of nations, such as the United States, and this helped in spurring on other maritime nations into ratifying the Convention due to their eagerness to protect their shipowners competitiveness.

A month after the 1978 conference the Amoco Cadiz ran aground off Brittany in France, reminding the world of the need and importance for strict regimes to avoid and control oil pollution. Sufficient States had ratified MARPOL by October 1982, and the MARPOL 1973/78 Convention entered into force on 2 October 1983.

The International Convention for the Prevention of Pollution from Ships (MARPOL) is the main international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes.

The MARPOL Convention, as it is already mentioned, was adopted on 2 November 1973 at IMO. The Protocol of 1978 was adopted in response to a spate of tanker accidents in 1976-1977. As the 1973 MARPOL Convention had not yet entered into force, the 1978 MARPOL Protocol absorbed the parent Convention. The combined instrument entered into force on 2 October 1983. In 1997, a Protocol was adopted to amend the Convention and a new Annex VI was added which entered into force on 19 May 2005. MARPOL has been updated by amendments through the years.
The Convention includes regulations aimed at preventing and minimizing pollution from ships - both accidental pollution and that from routine operations - and currently includes six technical Annexes. Special Areas with strict controls on operational discharges are included in most Annexes.

2.2.1 Annexes

*Annex I  Regulations for the Prevention of Pollution by Oil (entered into force 2 October 1983)

Covers prevention of pollution by oil from operational measures as well as from accidental discharges; the 1992 amendments to Annex I made it mandatory for new oil tankers to have double hulls and brought in a phase-in schedule for existing tankers to fit double hulls, which was subsequently revised in 2001 and 2003. 13

MARPOL Annex I, the first implementation made by MARPOL 73/78 is one of the most important international marine environmental conventions. The convention was created in order to minimize pollution of the oceans by vessels. The convention’s purpose is to protect the marine environment through the eradication of pollution by oil and other harmful substances and the minimization of accidental discharge of such substances. Annex I was first introduced during the 1973 international Convention for the Prevention of Pollution from Ships and it was additionally pushed to be enforced during the 1978 conference on Tanker Safety and Pollution Prevention. Annex I, was finally enforced on the 2nd of October 1983, and it details the prevention of pollution by oil and oily water.

The first half of Annex I has to do with engine room waste. There is a lot of new equipment and technology which was developed to prevent waste such as:

- Oily Water Separators (OWS).
- Oil Content Meters (OCM).
- Port reception facilities.

The second half of Annex I has more to do with cleaning the tanks and cargo areas. A technology that has greatly helped improve efficiency and environmental protection in these areas is the Oil Discharge Monitoring Equipment (ODME).

-The 1984 Amendments

Even though Annex I had entered into force, there was still work to be done in reviewing the Convention and confirming it was being implemented properly. The first amendments to MARPOL 73/78 were adopted in 1984 and they entered into force in 1986. They were created to ameliorate and strengthen the existing regulations, such as Regulation 25 regarding subdivision and stability -intended to ensure that tankers can survive a certain amount of 13 IMO, Conventions ,List of Conventions ,International Convention for the Prevention of Pollution from Ships (MARPOL)
damage. Some regulations were overlooked or moderated. For example the transportation of ballast water in cargo tanks was now allowed in certain conditions, this was based on studies showing that this was appropriate.

- The 1991 Amendments

In 1991, further amendments were introduced to Annex I, which entered into force in 1993. The amendments required oil tankers and other ships to carry an oil pollution emergency plan (SOPEP).

SOPEP stands for Ship oil pollution emergency plan and as per the MARPOL 73/78 requirement under Annex I, all ships with 400 GT and above must carry an oil prevention plan according to the norms and guidelines laid down by IMO under MEPC (Marine Environmental Protection Committee) act. The Gross tonnage requirement for oil tanker, according to SOPEP, reduces to 150 GT because oil itself is a kind of cargo which doubles the risk of oil pollution.

The Master and the chief officer of the ship are in charge of the implementation of SOPEP on board. The emergency plan also describes how the master, officers and the crew of the ship should tackle various oil spill scenarios that may occur. As for oil tankers the action plan widens concerning cargo handling and cargo tanks containing huge amounts of oil.

- The 1992 amendments - prevention of oil pollution in the event of collision or stranding

The Exxon Valdez, in 1989, ran aground in the northeastern portion of Prince William Sound, spilling about one-fifth of its cargo. It was the largest crude oil spill at the time in US waters. The spill probably earned the biggest media coverage to date. The U.S. public demanded action and it duly got it. The United States introduced its Oil Pollution Act of 1990 (OPA 90), which made it obligatory for all tanker ships travelling to U.S. ports to have double hulls.

(Photo: NOAA) Exxon Valdez spilling oil into the waters of Prince William Sound. This was the worst environmental disaster in the United States' history.
The United States also went to IMO, asking for double hulls to be made a compulsory requirement of MARPOL. The effect of the Exxon Valdez spill was duly noted by IMO and MEPC and they immediately began discussions on how the U.S. suggestions could be executed. There was resistance from the oil industry, as on previous occasions, to double hulls being made obligatory, mainly due to the cost of modifying existing tankers.

During that time, several IMO Member States stated that other designs should be approved as equal and that measures for already existing ships should also be contemplated.

In 1991 a study was funded by the tanker ship and oil industry and carried out by IMO. The study looked into the comparative performances of the double-hull and mid-height deck tanker designs. It ended in January 1992 and concluded that the two designs could be considered as equal, even though the two designs give different outflow efficiency under specific conditions. Ultimately, MEPC agreed to make double hulls or alternative designs mandatory "provided that such methods ensure the same level of protection against pollution in the event of a collision or stranding", however the alternative design methods must be approved by the MEPC.

Amendments to Annex I of MARPOL 73/78 were adopted. The amendments introduced two new regulations, 13F and 13G, relating to standards for design and construction of new and existing oil tankers. Regulation 13F was adopted in March 1992 and entered into force in July 1993. This regulation concerns new tankers (delivered on or after the 6th of July 1996), while already existing tankers must conform to the requirements of regulation 13F not later than 30 years after their date of delivery. Tanker ships between 600 dwt and 5,000 dwt must be fitted with double bottom or double sides with a separated space that has to be at least 0.76 meters. Tanker ships of 5,000 dwt and above are required to have a double hull, which means double bottom and double sides, separated by a space of up to two meters.
The MEPC also adopted Regulation 13G which concerns already existing tankers. The regulation, makes preparations for an enhanced program of inspections to be implemented, specifically for tanker ships more than five years old.

Regulation 13G also allowed for future recognition of other operational or structural arrangements as surrogates to the protective measures in the Regulation, such as hydrostatic balance loading (HBL). It was foreseen that older tankers which could not be revamped to the new standard for economic reasons, would obviously be scrapped.

The MEPC adopted a resolution suggesting that Governments of member states should take initiatives in co-operation with the shipbuilding and shipping industries, to create scrapping facilities at a world-wide level. This resolution’s ambition was to promote development and research programs and also to provide technical assistance to developing countries in developing ship scrapping facilities.

The MEPC also endorsed amendments to MARPOL, which severely reduced the amount of oil which could be discharged into the sea caused by routine operations, forbidding non-tankers to discharge oily wastes if the oil content exceeds 15 parts per million and allowing tankers to discharge oily mixtures only at a rate of 30 liters per nautical mile (and only outside special areas).

-The 1994 amendments -Implementation

The MEPC adopted amendments to MARPOL in November 1994, which aimed to improve the implementation of the Convention, making it plausible for ships to be inspected during their stay at ports of other members of MARPOL, to make certain that the crew of the ship which is being inspected is fit to carry out vital shipboard procedures relating to marine pollution prevention. The amendments, entered into force on the 3rd of March 1996 and also applied to Annex II concerning pollution by noxious liquid substances, Annex III containing regulations for the prevention of pollution by harmful substances in packaged form and Annex V which deals with garbage.

Alike amendments were made in May 1995 to the International Convention for the Safety of Life at Sea (SOLAS). A number of IMO Conventions include provisions for port State control inspections but formerly these have been restricted primarily to certification and the physical condition of the ship and the ship’s equipment.

Extending port State control to operational requirements was viewed as a crucial way of enhancing the efficiency with which anti-pollution conventions are implemented and international safety is achieved.

-Achievements prior to the 2017 Amendments

In 1990, MARPOL 73/78 was credited with making "a substantial positive impact in decreasing the amount of oil that enters the sea" by the National Research Council Marine Board of the United States. A study conducted by the Board showed that in 1981, approximately 1,470,000 tons of oil entered the world's oceans as a result of shipping
operations. Most of it came from routine operations, such as discharges of machinery wastes and tank washings from oil tankers (the latter alone contributed 700,000 tons). Accidental pollution contributed to less than 30% of the total. It was estimated that oil pollution from ships had been reduced to 568,800 tons by 1989. Tanker operations contributed to only 158,000 tons of this.

Furthermore, although the 1978 Protocol did not enter into force until 1983, many of its requirements were nevertheless already being implemented. The "load on top" system, for example, had been implemented since 1978 and was installed on many tankers because it reduced the amount of oil wasted during routine operations thereby increasing profits. The "new ship" and "new tanker" definitions included in the original 1973 Convention and the 1978 Protocol also meant that all tankers built after those dates already complied with MARPOL 73/78 requirements.

Today, tankers safely transport 1/3 of the crude oil around the world by sea including 50 percent of US oil imports. MARPOL measures introduced after major accidents have contributed to the fact that today a tanker is more likely to be well constructed and operated. The fact that MARPOL measures have essentially been triggered by disasters is not necessarily a bad thing. The ramifications of the public outcry over oil slicks or tar balls on beaches have been to ensure that the oil majors who transport crude oil around the world are prepared to invest in safety and pollution prevention features -because an accident, apart from its costs on human life or physical terms -could cost them dearly in negative publicity.

- The 2017 Amendments

MEPC adopted the amendments to Regulation 12 of Annex I of the MARPOL Convention. The amendments entered into force on the 1st of January 2017. The amendments have re-structured the provisions of regulation 12 of MARPOL Annex I corresponding to tanks for oil residues (sludge) on the requirements for discharge connections and common piping arrangement to make certain that oil residues are properly jettisoned.

Oil residue may be disposed of directly from the oil residue tank(s) to reception facilities through the standard discharge connection referred to in regulation 13, or to any other approved means of disposal of oil residue, such as an incinerator, auxiliary boiler suitable for burning oil residues or other acceptable means which shall be annotated in item 3.2 of the Supplement to International Oil Pollution Prevention (IOPP) Certificate Form A or B.

Oil residue (sludge) tank(s) shall be provided and:

- shall be of adequate capacity, having regard to the type of machinery and length of voyage, to receive the oil residues (sludge) which cannot be dealt with
- shall be provided with a designated pump that is capable of taking suction from the oil residue (sludge) tank(s) for disposal of oil residue (sludge)
- shall have no discharge connections to the bilge system, oily bilge water holding tank(s), tank top or oily water separators, except that:
1. the tank(s) may be fitted with drains, with manually operated self-closing valves and arrangements for subsequent visual monitoring of the settled water, that lead to an oily bilge water holding tank or bilge well, or an alternative arrangement, provided such arrangement does not connect directly to the bilge discharge piping system; and

2. the sludge tank discharge piping and bilge-water piping may be connected to a common piping leading to the standard discharge connection referred to in regulation 13; the connection of both systems to the possible common piping leading to the standard discharge connection referred to in regulation 13 shall not allow for the transfer of sludge to the bilge system

- shall not be arranged with any piping that has direct connection overboard, other than the standard discharge connection referred to in regulation 13 and
- shall be designed and constructed so as to facilitate their cleaning and the discharge of residues to reception facilities.

Ships constructed before the 1st of January 2017 shall be arranged to comply with paragraph 3.3 of this regulation not later than the first renewal survey carried out on or after the 1st of January 2017.

*Annex II Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk (entered into force 2 October 1983)

Details the discharge criteria and measures for the control of pollution by noxious liquid substances carried in bulk; some 250 substances were evaluated and included in the list appended to the Convention; the discharge of their residues is allowed only to reception facilities until certain concentrations and conditions (which vary with the category of substances) are complied with. In any case, no discharge of residues containing noxious substances is permitted within 12 miles of the nearest land.

While the BCH Code addressed the design and construction of chemical tankers to ensure safe transport of chemical substances, Annex II of the 1973 MARPOL Convention was concerned with preventing or reducing the operational discharge and accidental release of these substances into the sea. The regulations were the first to focus on operational discharges of chemicals from operations such as tank washing. However, the regulations required Governments to guarantee reception facilities would be available to receive chemical residues -and this was seen as a dilemma even while States were adopting the convention at the 1973 Conference. Annex I was based on the belief that all oils are harmful substances and should be prevented from entering the sea, whereas Annex II recognized the wide diversity in biological and physical properties of the substances it covered. As a result, the substances were divided into four categories which were classified A to D, according to the hazard they present to marine resources, human health and or amenities.

• Category A -Noxious liquid substances which if discharged into the sea from tank cleaning or de-ballasting operations would present a major hazard to either marine resources or human health or cause serious harm to amenities or other legitimate uses of the sea and therefore
justify the application of stringent anti-pollution measures. Examples are acetone cyanohydrin, carbon disulphide, cresols, naphthalene and tetraethyl lead.

**Category B** - Noxious liquid substances which if discharged into the sea from tank cleaning or de-ballasting operations would present a hazard to either marine resources or human health or cause harm to amenities or other legitimate uses of the sea and therefore justify the application of special anti-pollution measures. Examples are acrylonitrile, carbon tetrachloride, ethylene dichloride and phenol.

**Category C** - Noxious liquid substances which if discharged into the sea from tank cleaning or de-ballasting operations would present a minor hazard to either marine resources or human health or cause minor harm to amenities or other legitimate uses of the sea and therefore require special operational conditions. Examples are benzene, styrene, toluene and xylene.

**Category D** - Noxious liquid substances which if discharged into the sea from tank cleaning or de-ballasting operations would present a recognizable hazard to either marine resources or human health or cause minimal harm to amenities or other legitimate uses of the sea and therefore require some attention in operational conditions. Examples are acetone, phosphoric acid and tallow.

The Annex also specified "other liquid substances" which were not included in Categories A, B, C or D and therefore represent no harm when discharged into the sea from tank cleaning or ballasting operations. These substances included coconut oil, ethyl alcohol, molasses, olive oil and wine. A list of approximately 250 noxious liquid substances, with categorization, was given in Appendix II to the Annex. The discharge of these substances varies according to the hazards they present.

-Review of Annex II

The MEPC, in 1992 agreed to review all the provisions in Annex II. The intention was to simplify the requirements in order to encourage more widespread implementation of the Annex. MEPC also agreed to review the categorization system. The decision to review the Annex entirely was influenced by a number of developments as follow.

Firstly, developments in ship technology meant that stripping of tanks had ameliorated to the extent that only trace amounts of residues would be left in tanks after unloading and as a result, the limits on the discharges of substances could also be substantially reduced.

Improvements in technology have enabled IMO to reconsider the amount of discharge permitted to enter the marine environment and allowed IMO to reconsider the number of defined pollution categories.

Another matter was improved comprehension of the environmental impact of chemicals on the marine environment. In the existing product categorization, Annex II placed quite alot of emphasis on acute aquatic toxicity, tainting of fish and bioaccumulation with associated harmful effects, however it was being acknowledged that other properties were equally
important, such as chronic aquatic toxicity, and the effect on wildlife or seabed of substances that would sink or continuously float on the surface.

-The 2007 Amendments

The IMO’s Marine Environment Protection Committee (MEPC) adopted a revised MARPOL 73/78 Annex II Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk in 2004 which came into effect on the 1st of January 2007 and applied to both new and existing ships. This revised Annex used a new four-category pollution system for noxious liquid substances; the existing A, B, C and D category system became X, Y and Z.

-The 2014 Amendments

The 2012 amendments to the IBC Code which were adopted by IMO Resolutions MSC.340(91) and MEPC.225(64), entered into force on the 1st of June 2014, and revised Chapter 17 (the summary of minimum requirements) and Chapter 18 (the list of products to which the Code does not apply). The amendments applied to new and existing vessels which had IBC/BCH Code Certificates of Fitness and Noxious Liquid Substances. Offshore supply vessels with certificates of Fitness in compliance with IMO Resolution A.673(16), as amended were also affected.

New certificates complying with these amendments had to be on board by the 1st of June 2014. All loading after this date had to be in accordance with the new certificates. When cargo was loaded before the 1st of June 2014 and unloaded after this date, the relevant IBC Code provisions at the time of loading should have applied until the cargo had been unloaded.

-The 2016 Amendments

The new requirements were introduced into the IBC Code by IMO in order to make the provision of a stability instrument compulsory on board all chemical tankers. The stability instrument must be capable of verifying compliance with intact and damage stability requirements.

*Annex III Prevention of Pollution by Harmful Substances Carried by Sea in Packaged Form (entered into force 1 July 1992)

Contains general requirements for the issuing of detailed standards on packing, marking, labelling, documentation, stowage, quantity limitations, exceptions and notifications.
For the purpose of this Annex, “harmful substances” are those substances which are identified as marine pollutants in the International Maritime Dangerous Goods Code (IMDG Code) or which meet the criteria in the Appendix of Annex III.

The aim behind the regulations contained in Annex III of MARPOL was to identify marine pollutants in order that they could be packed and stowed on board ships so as to minimize accidental pollution as well as to aid in recovery by using clear marks to distinguish them from other (less harmful) cargoes.
The rules on discharging harmful goods are straightforward, "Jettisoning of harmful substances carried in packaged form shall be prohibited, except where necessary for the purpose of securing the safety of the ship or saving life at sea".

The Annex also stipulated that "Appropriate measures based on the physical, chemical and biological properties of harmful substances shall be taken to regulate the washing of leakages overboard, provided that compliance with such measures would not impair the safety of the ship and persons on board."

Annex III pertains to all ships carrying harmful substances in packaged form, freight containers, portable tanks or road and rail tank wagons. The regulations require the issuing of detailed standards on packaging, marking, labeling, documentation, stowage, quantity limitations, exceptions and notifications, for preventing or minimizing pollution by harmful substances.

Obstacles however, hampered the implementation of the Annex due to the lack of a clear definition of harmful substances carried in packaged form. This was remedied by amendments to the International Maritime Dangerous Goods Code (IMDG Code) to include marine pollutants.

The IMDG Code was first adopted by IMO in 1965 and lists hundreds of specific dangerous goods together with detailed advice on storage, packaging and transportation. The amendments extending the Code to cover marine pollutants, which entered into force in 1991, added the identifier "marine pollutant" to all substances classified as such. All packages containing marine pollutants must be marked with a standard marine pollutant symbol. Simultaneously Annex III of MARPOL was also amended to make it clear that "harmful substances' are those substances which are identified as marine pollutants in the International Maritime Dangerous Goods Code (IMDG Code)."

Annex III was optional under the terms of the 1973 Convention which meant that States who had signed up to MARPOL 73/78 were not required to adopt the Annex at the same time. Annexes IV and V were also optional and would enter into force 12 months later when not less than 15 States with combined merchant shipping tonnage of more than 50 percent of the world fleet had ratified them. Annex III received sufficient ratifications by 1991 and entered into force on the 1st of July 1992. On the 1st of October 1998 it was ratified by 87 States, representing 79.13 percent of world merchant shipping.

-Annex III today
The main changes affecting Annex III today relate to the IMDG Code, rather than to any developments in the Annex itself. The Maritime Safety Committee (MSC) adopted Amendment 29 to the IMDG Code in May 1998, which was aimed at bringing the Code into line with the tenth revised edition of the United Nations Recommendations on the Transport of Dangerous Goods, it came into effect on the 1st of January 1999, with a transitional period to the 1st of July 1999.
Amendment 29 also includes a revised classification of marine pollutants, based on the work carried out by GESAMP (Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection) on hazard profiles.

Meanwhile, the IMDG Code was being reformatted to make it more user-friendly and easily comprehensible. The Code appeared in four volumes, but the reformatted Code appeared in two volumes: one covering the general introduction, with information about the nine classes of dangerous goods, packaging and portable tanks; the second incorporating the list of substances plus the index.

The two-volume Code is divided into seven parts:

**Volume 1** contains (parts 1, 2, 4, 5, 6 and 7 of the Code) with sections on:
- general provisions, definitions, training
- Classification
- Packing and Tank Provisions
- Consignment Procedures
- Construction and Testing of packaging’s, IBCs, large packaging’s, portable tanks, MEGCs and road tank vehicles
- Transport Operations

**Volume 2** contains: part 3 (Dangerous Goods List, special provisions and exceptions), appendix A (generic and N.O.S. Proper Shipping Names), appendix B (Glossary of terms) and an index.

*The Supplement* contains the following texts related to the IMDG Code:
- EMS Guide
- Medical First Aid Guide
- Reporting Procedures
- Packing Cargo Transport Units
- Safe Use of Pesticides
- INF Code

- Regulations for the prevention of pollution by harmful substances carried by sea in packaged form

**Regulation 1**

*Application*

1 Unless expressly provided otherwise, the regulations of this Annex apply to all ships carrying harmful substances in packaged form.

.1 For the purpose of this Annex, "harmful substances" are those substances which are identified as marine pollutants in the International Maritime Dangerous Goods Code (IMDG Code) or which meet the criteria in the Appendix of this Annex.

.2 For the purposes of this Annex, "packaged form" is defined as the forms of containment specified for harmful substances in the IMDG Code.
2 The carriage of harmful substances is prohibited, except in accordance with the provisions of this Annex.
3 To supplement the provisions of this Annex, the Government of each Party to the Convention shall issue, or cause to be issued, detailed requirements on packing, marking, labeling, documentation, stowage, quantity limitations and exceptions for preventing or minimizing pollution of the marine environment by harmful substances.
4 For the purposes of this Annex, empty packaging’s which have been used previously for the carriage of harmful substances shall themselves be treated as harmful substances unless adequate precautions have been taken to ensure that they contain no residue that is harmful to the marine environment.
5 The requirements of this Annex do not apply to ship's stores and equipment.

**Regulation 2**

*Packing*
Packages shall be adequate to minimize the hazard to the marine environment, having regard to their specific contents.

**Regulation 3**

*Marking and labeling*
1 Packages containing a harmful substance shall be durably marked or labelled to indicate that the substance is a harmful substance in accordance with the relevant provisions of the IMDG Code.
2 The method of affixing marks or labels on packages containing a harmful substance shall be in accordance with the relevant provisions of the IMDG Code.

**Regulation 4**

*Documentation*
1 Transport information relating to the carriage of harmful substances shall be in accordance with the relevant provisions of the IMDG Code and shall be made available to the person or organization designated by the port State authority.
2 Each ship carrying harmful substances shall have a special list, manifest or stowage plan setting forth, in accordance with the relevant provisions of the IMDG Code, the harmful substances on board and the location thereof. A copy of one of these documents shall be made available before departure to the person or organization designated by the port State authority.

**Regulation 5**

*Stowage*
Harmful substances shall be properly stowed and secured so as to minimize the hazards to the marine environment without impairing the safety of the ship and persons on board.

**Regulation 6**

*Quantity limitations*
Certain harmful substances may, for sound scientific and technical reasons, need to be prohibited for carriage or be limited as to the quantity which may be carried aboard any one
ship. In limiting the quantity, due consideration shall be given to size, construction and equipment of the ship, as well as the packaging and the inherent nature of the substances.

**Regulation 7**

*Exceptions*

1 Jettisoning of harmful substances carried in packaged form shall be prohibited, except where necessary for the purpose of securing the safety of the ship or saving life at sea.
2 Subject to the provisions of the present Convention, appropriate measures based on the physical, chemical and biological properties of harmful substances shall be taken to regulate the washing of leakages overboard, provided that compliance with such measures would not impair the safety of the ship and persons on board.

**Regulation 8**

*Port State control on operational requirements*

1 A ship when in a port or an offshore terminal of another Party is subject to inspection by officers duly authorized by such Party concerning operational requirements under this Annex.
2 Where there are clear grounds for believing that the master or crew are not familiar with essential shipboard procedures relating to the prevention of pollution by harmful substances, the Party shall take such steps, including carrying out detailed inspection and, if required, will ensure that the ship shall not sail until the situation has been brought to order in accordance with the requirements of this Annex.
3 Procedures relating to the port State control prescribed in article 5 of the present Convention shall apply to this regulation.
4 Nothing in this regulation shall be construed to limit the rights and obligations of a Party carrying out control over operational requirements specifically provided for in the present Convention.

*Annex IV Prevention of Pollution by Sewage from Ships (entered into force 27 September 2003)*

Contains requirements to control pollution of the sea by sewage; the discharge of sewage into the sea is prohibited, except when the ship has in operation an approved sewage treatment plant or when the ship is discharging comminuted and disinfected sewage using an approved system at a distance of more than three nautical miles from the nearest land; sewage which is
not comminuted or disinfected has to be discharged at a distance of more than 12 nautical miles from the nearest land.

The discharge of raw sewage into the sea can create a health hazard, while in coastal areas, sewage can also lead to oxygen depletion and an obvious visual pollution - a major problem for countries with large tourist industries.

The main sources of human-produced sewage are land-based - such as municipal sewers or treatment plants.

It is generally considered that on the high seas, the oceans are capable of assimilating and dealing with raw sewage through natural bacterial action and therefore the regulations in Annex IV of MARPOL prohibit ships from discharging sewage within four miles of the nearest land, unless they have in operation an approved treatment plant. Between 4 and 12 miles from land, sewage must be comminuted and disinfected before discharge.

Annex IV contains a set of regulations regarding the discharge of sewage into the sea from ships, including regulations regarding the ships’ equipment and systems for the control of sewage discharge, the provision of facilities at ports and terminals for the reception of sewage, and requirements for survey and certification.

- Shipboard Sewage Pollution Sources
  - drainage and other wastes from any form of toilets and urinals
  - drainage from medical premises (dispensary, sickbay, etc.) via wash basins, wash tubs and scuppers located in such premises
  - drainage from spaces containing living animals
  - other waste waters when mixed with the drainages defined above.

(Regulations not applicable to the disposal of: drainage from dishwasher, shower, laundry, bath and Washbasin drains - grey water).

- Ships application
  - new ships of ≥ 400 gross tons
  - new ships < 400 gross tons certified to carry over 15 persons

  - (new ships: building contract or keel laid on/after 27 September 2003 or delivered on/after 27 September 2006)
  - existing ships of ≥ 400 gross tons
  - existing ships < 400 gross tons certified to carry over 15 persons (on or after 27 September 2008)

- Surveys

Every ship which, in accordance with regulation 2, is required to comply with the provisions of this Annex shall be subject to the surveys specified below:

  - An initial survey before the ship is put in service or before the Certificate required under regulation 5 of this Annex is issued for the first time, which shall include a complete survey of its structure, equipment, systems, fittings, arrangements and material in so far as the ship is covered by this Annex. This survey shall be such as to
ensure that the structure, equipment, systems, fittings, arrangements and materials fully comply with the applicable requirements of this Annex.

- A renewal survey at intervals specified by the Administration, but not exceeding five years, except where regulation 8.2, 8.5, 8.6 or 8.7 of this Annex is applicable. The renewal survey shall be such as to ensure that the structure, equipment, systems, fittings, arrangements and materials fully comply with applicable requirements of this Annex.

- An additional survey, either general or partial, according to the circumstances, shall be made after a repair resulting from investigations prescribed in paragraph 4 of this regulation, or whenever any important repairs or renewals are made. The survey shall be such as to ensure that the necessary repairs or renewals have been effectively made, that the material and workmanship of such repairs or renewals are in all respects satisfactory and that the ship complies in all respects with the requirements of this Annex.

-Issue or endorsement of Certificate

- An International Sewage Pollution Prevention Certificate shall be issued, after an initial or renewal survey in accordance with the provisions of regulation 4 of this Annex, to any ship which is engaged in voyages to ports or offshore terminals under the jurisdiction of other Parties to the Convention. In the case of existing ships this requirement shall apply five years after the date of entry into force of this Annex.

- Such Certificate shall be issued or endorsed either by the Administration or by any persons or organization* duly authorized by it. In every case, the Administration assumes full responsibility for the Certificate.

-Form of Certificate

The International Sewage Pollution Prevention Certificate shall be drawn up in the form corresponding to the model given in the appendix to this Annex and shall be at least in English, French or Spanish. If an official language of the issuing country is also used, this shall prevail in case of a dispute or discrepancy.

-Duration and validity of Certificate

- An International Sewage Pollution Prevention Certificate shall be issued for a period specified by the Administration which shall not exceed five years.

- Notwithstanding the requirements of paragraph 1 of this regulation, when the renewal survey is completed within three months before the expiry date of the existing Certificate, the new Certificate shall be valid from the date of completion of the renewal survey to a date not exceeding five years from the date of expiry of the existing Certificate.
If a Certificate is issued for a period of less than five years, the Administration may extend the validity of the Certificate beyond the expiry date to the maximum period specified in paragraph 1 of this regulation.

If a renewal survey has been completed and a new Certificate cannot be issued or placed on board the ship before the expiry date of the existing Certificate, the person or organization authorized by the Administration may endorse the existing Certificate and such a Certificate shall be accepted as valid for a further period which shall not exceed five months from the expiry date.

If a ship at the time when a Certificate expires is not in a port in which it is to be surveyed, the Administration may extend the period of validity of the Certificate but this extension shall be granted only for the purpose of allowing the ship to complete its voyage to the port in which it is to be surveyed and then only in cases where it appears proper and reasonable to do so. No Certificate shall be extended for a period longer than three months, and a ship to which an extension is granted shall not, on its arrival in the port in which it is to be surveyed, be entitled by virtue of such extension to leave that port without having a new Certificate. When the renewal survey is completed, the new Certificate shall be valid to a date not exceeding five years from the date of expiry of the existing Certificate before the extension was granted.

A Certificate issued to a ship engaged on short voyages which has not been extended under the foregoing provisions of this regulation may be extended by the Administration for a period of grace of up to one month from the date of expiry stated on it. When the renewal survey is completed, the new Certificate shall be valid to a date not exceeding five years from the date of expiry of the existing Certificate before the extension was granted.

In special circumstances, as determined by the Administration, a new Certificate need not be dated from the date of expiry of the existing Certificate as required by paragraph 2.2, 5 or 6 of this regulation. In these special circumstances, the new Certificate shall be valid to a date not exceeding five years from the date of completion of the renewal survey.

-Sewage systems

Every ship which, in accordance with regulation 2, is required to comply with the provisions of this Annex shall be equipped with one of the following sewage systems:

- a sewage treatment plant which shall be of a type approved by the Administration, taking into account the standards and test methods developed by the Organization, or
- a sewage comminuting and disinfecting system approved by the Administration. Such system shall be fitted with facilities to the satisfaction of the Administration, for the temporary storage of sewage when the ship is less than 3 nautical miles from the nearest land, or
- a holding tank of the capacity to the satisfaction of the Administration for the retention of all sewage, having regard to the operation of the ship, the number of
persons on board and other relevant factors. The holding tank shall be constructed to the satisfaction of the Administration and shall have a means to indicate visually the amount of its contents.

-Discharge sewage

The discharge of sewage into the sea is prohibited, except when:

- the ship is discharging comminuted and disinfected sewage using an approved system at a distance of more than 3 nm from the nearest land or
- the ship is discharging sewage which is not comminuted and disinfected at a distance of more than 12 nm from the nearest land, provided that in any case, the sewage stored in holding tanks or sewage originating from spaces containing living animals, shall not be discharged instantaneously but at a moderate rate when ship is en route and proceeding at not less than 4 knots or
- the ship is discharging sewage using an approved sewage treatment plan

-Exceptions

The discharge of sewage into the sea is allowed when:

- securing the safety of life or the ship or
- the discharge of sewage is as result from damage to a ship or its equipment if all reasonable precautions have been taken before and after the occurrence of the damage, for the purpose of preventing or minimizing the discharge.

*Annex V Prevention of Pollution by Garbage from Ships (entered into force 31 December 1988)

Deals with different types of garbage and specifies the distances from land and the manner in which they may be disposed of; the most important feature of the Annex is the complete ban imposed on the disposal into the sea of all forms of plastics.

Garbage from ships can be just as deadly to marine life as oil or chemicals. The greatest danger comes from plastic, which can float for years. Fish and marine mammals can in some cases mistake plastics for food and they can also become trapped in plastic ropes, nets, bags and other items -even such innocuous items as the plastic rings used to hold cans of beer and drinks together.

It is clear that a good deal of the garbage washed up on beaches comes from people on shore - holiday-makers who leave their rubbish on the beach, fishermen who simply throw unwanted refuse over the side -or from towns and cities that dump rubbish into rivers or the sea. But in some areas most of the rubbish found comes from passing ships which find it convenient to throw rubbish overboard rather than dispose of it in ports. One estimate in the early 1980s suggested that more than six million cans and 400,000 bottles were being dumped into the sea
from ships every day. One estimate in the early 1980s suggested that more than six million cans and 400,000 bottles were being dumped into the sea from ships every day.

For a long while, many people believed that the oceans could absorb anything that was thrown into them, but this attitude has changed along with greater awareness of the environment. Many items can be degraded by the seas -but this process can take months or years.

The 1973 MARPOL Convention sought to eliminate and reduce the amount of garbage being dumped into the sea from ships. Under Annex V of the Convention, garbage includes all kinds of food, domestic and operational waste, excluding fresh fish, generated during the normal operation of the vessel and liable to be disposed of continuously or periodically.

-Disposal of garbage outside special areas

  • the disposal into the sea of all plastics, including but not limited to synthetic ropes, synthetic fishing nets, plastic garbage bags and incinerator ashes from plastic products which may contain toxic or heavy metal residues, is prohibited.
  • the disposal into the sea of the following garbage shall be made as far as practicable from the nearest land but in any case is prohibited if the distance from the nearest land is less than:
    1. 25 nautical miles for dunnage, lining and packing materials which will float.
    2. 12 nautical miles for food wastes and all other garbage including paper products, rags, glass, metal, bottles, crockery and similar refuse.
  • disposal into the sea less than 12 nautical miles may be permitted when it has passed through a comminuter or grinder and made as far as practicable from the nearest land but in any case is prohibited if the distance from the nearest land is less than 3 nautical miles. Such comminuted or ground garbage shall be capable of passing through a screen with openings no greater than 25 mm.

-Exceptions

Regulations of this Annex shall not apply to:

  • the disposal of garbage from a ship necessary for the purpose of securing the safety of a ship and those on board or saving life at sea
  • the escape of garbage resulting from damage to a ship or its equipment provided all reasonable precautions have been taken before and after the occurrence of the damage, for the purpose of preventing or minimizing the escape
  • the accidental loss of synthetic fishing nets, provided that all reasonable precautions have been taken to prevent such loss.

*Annex VI Prevention of Air Pollution from Ships (entered into force 19 May 2005)

Sets limits on sulphur oxide and nitrogen oxide emissions from ship exhausts and prohibits deliberate emissions of ozone depleting substances; designated emission control areas set
more stringent standards for SOx, NOx and particulate matter. A chapter adopted in 2011 covers mandatory technical and operational energy efficiency measures aimed at reducing greenhouse gas emissions from ships.

Apply to all ships of 400 gross tons and above which have to carry an International Air Pollution Prevention Certificate (IAPP Certificate). This certificate must be on board at delivery for a ship constructed (keel laid) after 19 May 2005. For ships constructed before this date, the IAPP certificate must be on board at the first scheduled dry-docking after 19 May 2005, but not later than 19 May 2008. Ships of less than 400 tons still have to comply with the legislation where applicable, but in their case the Administration may establish appropriate measures in order to ensure that Annex VI is complied with.

-General exceptions

Regulations of this Annex shall not apply to:

- any emission necessary for the purpose of securing the safety of a ship or saving life at sea
- any emission resulting from damage to a ship or its equipment:

1. provided that all reasonable precautions have been taken after the occurrence of the damage or discovery of the emission for the purpose of preventing or minimizing the emission and

2. except if the owner or the master acted either with intent to cause damage, or recklessly and with knowledge that damage would probably result.
CHAPTER 3:

3.1 Safety Of Life At Sea- SOLAS

The SOLAS Convention in its successive forms is generally regarded as the most important of all international treaties concerning the safety of merchant ships. The first version was adopted in 1914, in response to the Titanic disaster, the second in 1929, the third in 1948, and the fourth in 1960. The 1974 version includes the tacit acceptance procedure - which provides that an amendment shall enter into force on a specified date unless, before that date, objections to the amendment are received from an agreed number of Parties.

As a result the 1974 Convention has been updated and amended on numerous occasions. The Convention in force today is sometimes referred to as SOLAS, 1974, as amended.

*Technical provisions

The main objective of the SOLAS Convention is to specify minimum standards for the construction, equipment and operation of ships, compatible with their safety. Flag States are responsible for ensuring that ships under their flag comply with its requirements, and a number of certificates are prescribed in the Convention as proof that this has been done. Control provisions also allow Contracting Governments to inspect ships of other Contracting States if there are clear grounds for believing that the ship and its equipment do not substantially comply with the requirements of the Convention - this procedure is known as port State control. The current SOLAS Convention includes Articles setting out general obligations, amendment procedure and so on, followed by an Annex divided into 14 Chapters.

*Chapter I - General Provisions

Includes regulations concerning the survey of the various types of ships and the issuing of documents signifying that the ship meets the requirements of the Convention. The Chapter also includes provisions for the control of ships in ports of other Contracting Governments.

*Chapter II-1 - Construction - Subdivision and stability, machinery and electrical installations

The subdivision of passenger ships into watertight compartments must be such that after assumed damage to the ship's hull the vessel will remain afloat and stable. Requirements for watertight integrity and bilge pumping arrangements for passenger ships are also laid down as well as stability requirements for both passenger and cargo ships.

The degree of subdivision - measured by the maximum permissible distance between two adjacent bulkheads - varies with ship's length and the service in which it is engaged. The highest degree of subdivision applies to passenger ships.

Requirements covering machinery and electrical installations are designed to ensure that services which are essential for the safety of the ship, passengers and crew are maintained under various emergency conditions.
"Goal-based standards" for oil tankers and bulk carriers were adopted in 2010, requiring new ships to be designed and constructed for a specified design life and to be safe and environmentally friendly, in intact and specified damage conditions, throughout their life. Under the regulation, ships should have adequate strength, integrity and stability to minimize the risk of loss of the ship or pollution to the marine environment due to structural failure, including collapse, resulting in flooding or loss of watertight integrity.

*Chapter II-2 - Fire protection, fire detection and fire extinction*

Includes detailed fire safety provisions for all ships and specific measures for passenger ships, cargo ships and tankers. They include the following principles: division of the ship into main and vertical zones by thermal and structural boundaries; separation of accommodation spaces from the remainder of the ship by thermal and structural boundaries; restricted use of combustible materials; detection of any fire in the zone of origin; containment and extinction of any fire in the space of origin; protection of the means of escape or of access for fire-fighting purposes; ready availability of fire-extinguishing appliances; minimization of the possibility of ignition of flammable cargo vapour.

*Chapter III - Life-saving appliances and arrangements*

The Chapter includes requirements for life-saving appliances and arrangements, including requirements for life boats, rescue boats and life jackets according to type of ship. The International Life-Saving Appliance (LSA) Code gives specific technical requirements for LSAs and is mandatory under Regulation 34, which states that all life-saving appliances and arrangements shall comply with the applicable requirements of the LSA Code.

*Chapter IV – Radiocommunications*

The Chapter incorporates the Global Maritime Distress and Safety System (GMDSS). All passenger ships and all cargo ships of 300 gross tonnage and upwards on international voyages are required to carry equipment designed to improve the chances of rescue following an accident, including satellite emergency position indicating radio beacons (EPIRBs) and search and rescue transponders (SARTs) for the location of the ship or survival craft. Regulations in Chapter IV cover undertakings by contracting governments to provide radiocommunication services as well as ship requirements for carriage of radiocommunications equipment. The Chapter is closely linked to the Radio Regulations of the International Telecommunication Union.

*Chapter V - Safety of navigation*

Chapter V identifies certain navigation safety services which should be provided by Contracting Governments and sets forth provisions of an operational nature applicable in general to all ships on all voyages. This is in contrast to the Convention as a whole, which only applies to certain
classes of ship engaged on international voyages.

The subjects covered include the maintenance of meteorological services for ships; the ice patrol service; routeing of ships; and the maintenance of search and rescue services.

This Chapter also includes a general obligation for masters to proceed to the assistance of those in distress and for Contracting Governments to ensure that all ships shall be sufficiently and efficiently manned from a safety point of view.

The chapter makes mandatory the carriage of voyage data recorders (VDRs) and automatic ship identification systems (AIS).

*Chapter VI - Carriage of Cargoes

The Chapter covers all types of cargo (except liquids and gases in bulk) "which, owing to their particular hazards to ships or persons on board, may require special precautions". The regulations include requirements for stowage and securing of cargo or cargo units (such as containers). The Chapter requires cargo ships carrying grain to comply with the International Grain Code.

*Chapter VII - Carriage of dangerous goods

The regulations are contained in three parts:

Part A - Carriage of dangerous goods in packaged form - includes provisions for the classification, packing, marking, labelling and placarding, documentation and stowage of dangerous goods. Contracting Governments are required to issue instructions at the national level and the Chapter makes mandatory the International Maritime Dangerous Goods (IMDG) Code, developed by IMO, which is constantly updated to accommodate new dangerous goods and to supplement or revise existing provisions.

Part A-1 - Carriage of dangerous goods in solid form in bulk - covers the documentation, stowage and segregation requirements for these goods and requires reporting of incidents involving such goods.

Part B covers Construction and equipment of ships carrying dangerous liquid chemicals in bulk and requires chemical tankers to comply with the International Bulk Chemical Code (IBC Code).

Part C covers Construction and equipment of ships carrying liquefied gases in bulk and gas carriers to comply with the requirements of the International Gas Carrier Code (IGC Code).

Part D includes special requirements for the carriage of packaged irradiated nuclear fuel, plutonium and high-level radioactive wastes on board ships and requires ships carrying such products to comply with the International Code for the Safe Carriage of Packaged Irradiated Nuclear Fuel, Plutonium and High-Level Radioactive Wastes on Board Ships (INF Code).

The chapter requires carriage of dangerous goods to be in compliance with the relevant

*Chapter VIII - Nuclear ships*

Gives basic requirements for nuclear-powered ships and is particularly concerned with radiation hazards. It refers to detailed and comprehensive Code of Safety for Nuclear Merchant Ships which was adopted by the IMO Assembly in 1981.

*Chapter IX - Management for the Safe Operation of Ships*

The Chapter makes mandatory the International Safety Management (ISM) Code, which requires a safety management system to be established by the shipowner or any person who has assumed responsibility for the ship (the "Company").

*Chapter X - Safety measures for high-speed craft*

The Chapter makes mandatory the International Code of Safety for High-Speed Craft (HSC Code).

*Chapter XI-1 - Special measures to enhance maritime safety*

The Chapter clarifies requirements relating to authorization of recognized organizations (responsible for carrying out surveys and inspections on Administrations' behalves); enhanced surveys; ship identification number scheme; and port State control on operational requirements.

*Chapter XI-2 - Special measures to enhance maritime security*

*Regulation XI-2/3* of the chapter enshrines the International Ship and Port Facilities Security Code (ISPS Code). Part A of the Code is mandatory and part B contains guidance as to how best to comply with the mandatory requirements. *Regulation XI-2/8* confirms the role of the Master in exercising his professional judgement over decisions necessary to maintain the security of the ship. It says he shall not be constrained by the Company, the charterer or any other person in this respect.

*Regulation XI-2/5* requires all ships to be provided with a ship security alert system. *Regulation XI-2/6* covers requirements for port facilities, providing among other things for Contracting Governments to ensure that port facility security assessments are carried out and that port facility security plans are developed, implemented and reviewed in accordance with the ISPS Code. Other regulations in this chapter cover the provision of information to IMO, the control of ships in port, (including measures such as the delay, detention, restriction of operations including movement within the port, or expulsion of a ship from port), and the specific responsibility of Companies.

*Chapter XII - Additional safety measures for bulk carriers*

The Chapter includes structural requirements for bulk carriers over 150 metres in length.
3.2 Historical Review

*Origin and early versions

The first version of SOLAS Treaty was passed in 1914 in response to the sinking of the RMS Titanic, which prescribed numbers of lifeboats and other emergency equipment along with safety procedures, including continuous radio watches. The 1914 treaty never entered into force due to the outbreak of the First World War.

Further versions were adopted in 1929 and 1948.

*1960 version

The 1960 Convention was adopted on 17 June 1960 and entered into force on 26 May 1965. It was the fourth SOLAS Convention and was the first major achievement for International Maritime Organization (IMO). It represented a considerable step forward in modernizing regulations and keeping up with technical developments in the shipping industry.

*1974 version

In 1974 a completely new Convention was adopted to allow SOLAS to be amended and implemented within a reasonable timescale, instead of the previous procedure to incorporate amendments, which proved to be very slow. Under SOLAS 1960, it could take several years for amendments to come into force since countries had to give notice of acceptance to IMO and there was a minimum threshold of countries and tonnage. Under SOLAS 1974, amendments enter into force via a tacit acceptance procedure – this allows an amendment to enter into force on a specified date, unless objections to an amendment are received from an agreed number of parties.

The 1974 SOLAS came into force on 25 May 1980,[1] 12 months after its ratification by at least 50 countries with at least 50% of gross tonnage. It has been updated and amended on numerous occasions since then and the Convention in force today is sometimes referred to as SOLAS, 1974, as amended.

In 1975 the assembly of the IMO decided that the 1974 convention should in future use SI (metric) units only.

*1988 version
In particular, amendments in 1988 based on amendments of International Radio Regulations in 1987 replaced Morse code with the Global Maritime Distress Safety System (GMDSS) and came into force beginning 1 February 1992. The issues covered by the treaty are set out in the list of sections (above).

*Later amendments*

The up-to-date list of amendments to SOLAS is maintained by the IMO. Previous amendments were made in May 2011. In 2015, another later amendment is the SOLAS Container Weight Verification Regulation VI/2. This regulation, implemented by the IMO Maritime Safety Committee (MSC) requires that the full weight of loaded containers must be obtained prior to being on boarded on an ocean vessel. Communicating a weight value has called for the introduction of a new Electronic Data Interchange (EDI) communication protocol called VGM (Verified Gross Mass) or VERMAS (Verification of Mass), and involves cooperation between ocean carriers, Freight Forwarders/NVOCCs, EDI providers as well as exporters. The regulation states that exporters (shippers) are ultimately responsible to obtain a verified container weight. Originally scheduled for implementation on July 1, 2016,[16] the regulation allows for flexibility and practical refinement according to the Maritime Safety Committee Memorandum #1548 to October 1, 2016.

**CHAPTER 4**

**Environmental Management in Shipping Industry**

4.1 **Ballast Water Management**

Ballast water is essential for the safe operation of ships. It is used to adjust the overall weight of the vessel and its internal distribution in order to keep the ship floating safely, upright and in a stable condition. It is used to compensate for different cargo loads that a ship may carry at different times, including during loading and unloading. It also provides stability and manoeuvrability during transit.

Ballast is defined as any solid or liquid that is brought on board a ship to increase stability. Ballasting is essential if a ship is carrying a heavy load in one hold and a lighter load in another, or when the ship is empty or if it faces rough seas.

Prior to the 1880s, ships used solid ballast materials such as rocks and sand, which had to be manually shoveled into cargo holds, and similarly discharged when cargo was to be loaded on board. Unfortunately, if not properly secured, solid ballast is prone to shifting in heavy seas causing instability. With the introduction of steel-hulled ships and pumping technology, water became the ballast of choice.

Water can be easily pumped in and out of ballast tanks and requires little manpower. When ships need ballast, water is pumped from the sea where the ship is located into the ships’ ballast water tanks, which adds weight to key parts of the ship. Ballast water is discharged at sea when it is no longer needed or when the weight of the ship needs to be lightened.
Today, ocean going vessels have ballast tanks incorporated into their design. The number and size of ballast tanks varies according to a ship’s type and design. Most ships are equipped with a range of ballast capabilities and capacities, but generally ballast equates to 25-30% of a ship’s dead weight tonnage.

4.1.1 The “disadvantages” of ballast water

The process of loading and unloading untreated ballast water poses a major threat to the environment, public health and the economy as ships become a vector for the transfer of organisms between ecosystems, from one part of the world to another.

Diagram: Ballast Water Management Procedures during voyage

Source: IMO, 2002

When ballast water is pumped into a ship many microscopic organisms and sediments can be introduced into a ship’s ballast tanks. These organisms include bacteria, microbes, small invertebrates, eggs, cysts and larvae of various species. Many of these organisms are able to survive in a ship’s ballast tanks. When the ballast water is discharged, the organisms are released into new environments. If suitable conditions exist in the new environment into which they are released, these species can survive, reproduce and become aquatic invasive species.

- 10 billion tonnes of ballast water is transported worldwide every year, which could fill ~4 million olympic sized swimming pools
- 7,000 species are transferred in ballast water every hour of everyday
- There is 1 new invasion every 9 weeks

The green crab, zebra mussel, and round goby are all examples of aquatic invasive species which can be found in Canadian waters.
Table: Invasive Aquatic Species (IAS)

<table>
<thead>
<tr>
<th>Name</th>
<th>Native to</th>
<th>Introduced to</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cholera Vibrio cholerea</td>
<td>Various strains with broad ranges</td>
<td>South America, Gulf of Mexico and other areas</td>
<td>Some cholera epidemics are reported to have been associated with ballast water</td>
</tr>
<tr>
<td>Clidoceran Water Flea</td>
<td>Black and Caspian Seas</td>
<td>Baltic Sea</td>
<td>Reproduces to form very large populations that dominate the zooplankton community and clog fishing nets and trawls, with associated economic impacts.</td>
</tr>
<tr>
<td>Chinese mitten crab</td>
<td>Northern Asia</td>
<td>Western Europe, Baltic Sea and west coast North America</td>
<td>Undergoes mass migrations for reproductive purposes. Burrows into river banks and dykes causing erosion and siltation. Preys on native fish and invertebrate species, causing local extinctions during population outbreaks. Interferes with fishing activities.</td>
</tr>
<tr>
<td>Toxic algae(red/brown/green)</td>
<td>Various species with broad ranges</td>
<td>Several species have been transferred to new areas in ships ballast water</td>
<td>May form harmful algae blooms. Depending on the species, can cause massive kills of marine life through oxygen depletion, release of toxins and or mucus. Can foul beaches and impact on tourism and recreation. Some species may contaminate filter-feeding shellfish and cause fisheries to be closed. Consumption of contaminated shellfish by humans may cause severe illness and death.</td>
</tr>
<tr>
<td>Round goby Neogobius melanostomus</td>
<td>Black, Azov and Caspian Seas</td>
<td>Baltic Sea and North America</td>
<td>Highly adaptable and invasive. Increases in numbers and spreads quickly. Competes for food and habitat with native fishes including commercially important species, and preys on their eggs and young. Spawns multiple times per season and survives in poor water quality.</td>
</tr>
</tbody>
</table>

Source: IMO, Marine Environment, Ballast Water Management System, Invasive Aquatic Species (IAS)

4.1.2 Ballast Water- The microorganisms

1. Taxonomic name: Dreissena polymorpha

   Common name: zebra mussel.

   Zebra mussels are native to the Caspian and Black Seas. They are now established in the UK, Western Europe, Canada and the USA. They compete with zooplankton for food, thus affecting natural food webs. They also interfere with the ecological functions of native molluscs and cause great economic damage. This species has been nominated as among 100 of the “World’s Worst” invaders.
**General Impacts:** zebra mussels filter organic and inorganic particles between 7 and 400 microns, competing with native planktivores for food. The net result is a sedimentation of previously suspended organic matter in the form of faeces and pseudofaeces, shifting energy and nutrient balances from the pelagic to the benthic zone. Increases in water clarity favour increased photosynthesis by rooted aquatic macrophytes, and negatively affect fish species that prefer slightly turbid conditions, such as walleye. Removal of green algae gives cyanobacteria a competitive advantage, as zebra mussels will stop filtering in the presence of cyanobacteria. Zebra mussels settle in high numbers on native mussels (Unionidaceae), causing suffocation, starvation, and energetic stress leading to death. Loss of native mussel populations has increased dramatically where zebra mussels are present, particularly in the Great Lakes and Hudson and Mississippi rivers. Dense colonization of hard substrates is beneficial to benthic invertebrates, as habitat complexity increases as does availability of organic matter. Spawning reefs of fishes such as lake trout are negatively affected by zebra mussel colonies.

**Geographical Range:** native range includes the Black, Caspian, and Azov seas; since the 1700’s its range has expanded westward to most of western Europe, UK, and North America, where it is found in the Great Lakes and all of the major river drainages east of the Rocky Mountains.

**Invasion pathways:** aquarium trade (possibly via aquarium dumping); floating vegetation/debris; ships ballast water (egg Great Lakes); ship/boat hull fouling (introduced to smaller lakes by overland transport on boat hulls and trailers); translocation of machinery.

**Local dispersal methods:** aquaculture (larvae may be transported during fish stocking); boats (biofouling); on animals, people (e.g. scuba diver’s wetsuits, or in scientific sampling equipment); and water currents (range expansion within North America has been very rapid due to downstream transport of planktonic larvae).

2. **Taxonomic name:** *Mnemiopsis leidyi*

**Common names:** Comb jelly

The comb jelly, *Mnemiopsis leidyi*, is endemic to temperate to subtropical estuaries along the North and South American Atlantic coast. It was first recorded in the Black Sea in 1982, where it became well established, occurring in massive numbers. It also spread rapidly to the Azov, Marmara and Eastern Mediterranean, and towards the end of 1999, was recorded in the Caspian Sea, where its biomass eventually exceeded levels ever recorded in the Black Sea.

*Mnemiopsis* feeds on the same zooplankton as many of the commercial fish species in the area, and had a devastating impact of the fisheries. Landings of anchovy, for example, dropped to one-third of their previous levels, causing losses of around $500 million per year. Similar reductions in the biomass of kilka were experienced in the Caspian.
The decrease in zooplankton caused by Mnemiopsis also had impacts on the food web, causing an increase in phytoplankton, and a decline in predatory fish species and seals.

More recently, the accidental introduction into the Black Sea of another comb jelly – Beroe cf ovata – which is a predator of Mnemiopsis, has resulted in a major decline of Mnemiopsis there, and a substantial recovery of the ecosystem.

3. **Taxonomic Name: Carcinus maenas**

   **Common Name:** European shore crab, green crab, strandkrabbe

This crab is native to Europe and northern Africa. It has been introduced to the USA, Australia and South Africa. It is euryhaline, and a voracious predator which, in some of the locations where it has been introduced, has caused the decline of other crab and bivalve species. This species has been included among the 100 of the “World’s Worst” invaders (by ISSG).

**General Impacts:** a voracious predator. Able to crush mussels, and is a potential threat to mussel farms.

**Geographical range:** in its native range (north western Europe, including western Baltic Sea), it is abundant on any kind of seashore in shallow waters (upper intertidal to shallow subtidal), including estuaries.

**Invasion pathways:** aquaculture, aquarium trade, live food trade, ships ballast water, hull fouling.

**Local dispersal methods:** boats, self-propelled, water currents.

4. **Taxonomic name: Alexandrium spp. and Gymnodinium spp.**

There are at least four species found in Australian waters that are believed to be introduced: Gymnodinium catenatum, Alexandrium minutum, A. tamarensis and A. catenella. All four are bloom-forming species and all produce resting cysts that can lie dormant in bottom sediments for several years. These cysts germinate to produce free swimming cells that reproduce asexually (by division into two cells). When environmental conditions are favorable, cell growth and division is rapid resulting in dense blooms of cells that can extend over large areas. Such blooms are usually short lived (several weeks) but may last for 6-10 weeks in the case of G. catenatum.
**Impacts:** the toxins produced by all four dinoflagellate species are accumulated by filter feeding shellfish such as oysters, mussels and scallops making them toxic to humans and causing Paralytic Shellfish Poisoning (PSP) when eaten. Symptoms of PSP range from nausea, vomiting, dizziness and tingling or numbness in the face in mild cases to muscular paralysis and death from respiratory paralysis in severe cases. Harmful algal blooms (commonly called Red tides) pose a major threat to the viability of both wild and shellfish fisheries and shellfish farming operations. Accumulation of toxins either directly, in the case of filter feeders, or through the food chain can lead to poisoning and sometimes mortality in a wide range of organisms including shellfish, finfish and marine mammals. Intense blooms of toxic (and non toxic) species can also reduce the survival of shellfish and finfish by clogging their gills and by reducing oxygen levels in waters affected by blooms.

**Distribution vectors:** viable cysts of both A. catenella and A. tamarense have been recovered from sediment in the ballast tanks of ships entering Australian ports which indicates that ballast water is a likely vector for the introduction and translocation of all four species. Translocation of cysts to other areas could also occur as a result of dredging operations or any other activity that redistribute infected sediments or can resuspend cysts in the water column. Cysts may also be moved with oysters or other shellfish seed stock. In infected areas that are subject to bloom events, the uptake of water for ship ballast or for other purposes such as the transport of live seafood products, could entrain motile cells and distribute these to previously uninfected areas.

5 .Taxonomic name: *Vibrio cholera*

A cholera epidemic (which is caused by Vibrio cholera), commenced in the Eastern Celebes (Indonesia) in 1091, and finally completed its encirclement of the globe in 1991. In South America, the epidemic started on the coast of Peru, and was later documented from several ports in Latin America. This led to the conclusion that it had been introduced by marine traffic. The introduction caused a serious health threat to thousands of people after consumption of seafood caught in affected areas. It then also entered the unchlorinated water supply in Peru’s cities, and caused thousands of deaths.

6.Taxonomic name: *Caulerpa taxifolia*

Common names: caulerpa, seaweed.

Caulerpa taxifolia was introduced to the Mediterranean around 1984, possibly as waste from the Monaco Aquarium. It is a tropical seaweed but it has adapted well to colder waters and wherever it has established itself. The strain of Caulerpa taxifolia which has colonized the Mediterranean has some unusual morphological and physiological characteristics with respect
to the tropical populations (longer fronds, a higher population density, adaptation to a large spectrum of temperatures, higher concentrations of toxic metabolites). The competitive success of Caulerpa taxifolia over Mediterranean native communities seems to be related to these characteristics but also to the production of toxic secondary metabolites.

**General Impacts:** dominant colonization by Caulerpa taxifolia leads to a considerable decrease of biodiversity. The rate of impoverishment of a population colonized by C. taxifolia reaches 75% if we count only the algae of Mediterranean communities. Most of the indigenous algae regress and tend to disappear. They suffer a drastic decrease of their biomass, which can reach 100%. C. taxifolia competes also with the Posidonia oceanica meadows, which is one of the most important ecosystems of the Mediterranean. When both species are in direct competition, the size thickness, number and longevity of the Posidonia leaves decrease and necrotic areas appear on them. The species composition of the invertebrate meiofauna and macrofauna is strongly modified by the presence of C. taxifolia. In terms of the number of individuals, the Amphipoda have been the most affected group while an increase in diversity was observed in Molluscs. For fish, the species number, the number of individuals, the biomass and the mean weight are significantly lower in habitats colonised by C. taxifolia.

**Geographical Range:** it is widely distributed throughout the tropical seas and is native to Brazil, Venezuela, Colombia, Costa Rica, Antilles, Gulf of Guinea, Red Sea, Somalia, Kenya, Tanzania, Madagascar, Maldives, Seychelles, Pakistan, India, Sri Lanka, Bangladesh, Malaysia, Indonesia, Philippines, Vietnam, China, Japan, Hawaii, Fiji, New Caledonia, North Australia. It was introduced to the Mediterranean Sea in the 1980s and covers more than 4630 ha. It now affects Monaco, France, Italy, Spain, Croatia and Tunisia. Recently it has been discovered in the Pacific and Atlantic Oceans, in East Australia, and in the summer of 2000, off southern California and southern Florida (USA).

**Invasion pathways to new location:** aquarium trade (intentional release of aquaria content), ships (accidental transport by anchors etc).

**Local dispersal methods:** boat (accidental transport by anchors etc), fishing activities (nets).

7.Taxonomic name: Neogobius melanostomus

**Common name:** round goby

The round goby is native to the Black Sea, Caspian Sea, Sea of Azov and related tributaries, but is now established in waterways of the USA and Canada. The species has been found to prey on darters, other small fish, and the eggs and fry of lake trout in laboratory experiments. It may also feed on the eggs and fry of sculpins, darters and longperch.
General Impacts: the numbers of native fish species have declined in areas where this goby has become abundant; sculpins have been particularly affected. This species has been found to prey on darters, other small fish, and lake trout eggs and fry in laboratory experiments. They also may feed on eggs and fry of sculpins, darters and longperch. Adults aggressively defend spawning sites and may occupy prime spawning areas, keeping natives out. Walleye anglers in Detroit report that at times all they can catch are gobies, which eagerly attack bait. This goby is established and apparently undergoing a population explosion in the Great Lakes. The goby was considered extremely abundant in the St. Clair River in 1994. Short trawls made in Lake Erie in October 1994 turned up 200 individuals. Frequent trawling in 1995 collected over 3,000 individuals near Fairport Harbor, Ohio (Knight, personal communication). Densities in Calumet Harbor exceed 20 per square meter (Marsden and Jude 1995). Gravid females and different size classes have been found in Lake Erie (Cavender, personal communication). Only two individuals have been reported from Lake Superior.

Geographical Range: marine to fresh water. The native range includes Eurasia including Black Sea, Caspian Sea, and Sea of Azov and tributaries (Miller 1986). This species was introduced into the St. Clair River and vicinity on the Michigan-Ontario border where several collections were made in 1990 on both the U.S. and the Canadian side. It is now found in waterways of the USA (States of Illinois, Indiana, Ohio, Pennsylvania, Wisconsin, Minnesota, New York) and of Canada (Ontario and Quebec).

Invasion pathways to new location: introduced into the Great Lakes via freighter ballast. Spread to Lake Superior by freighters operating within the Great Lakes.

Remarks: the diet of round gobies collected in the United States consists of aquatic insects, zebra mussels, and some native snails. Studies have shown a single goby can eat as many as 78 zebra mussels per day.

At any one time ballast water can naturally contain an estimated 7000 different species of such organisms comprising of plankton (microscopic plants and animals), bacteria and viruses, as we already mentioned above. It is estimated that approximately 7 billion tons of ballast water is transferred globally each year.

The Ballast Water Convention (BWC) was introduced by the International Maritime Organisation in 2004 to address the Control and Management of Ships’ Ballast Water and Sediments, and applies to all sea going ships greater than 400gt that use ballast water. The BWC will be considered ratified when a minimum of 30 IMO member states representing no less than 35% of world gross registered tonnage sign up to the convention.
The BWC ultimately requires ships to fit a ballast water treatment system conforming to Regulation D2 discharge performance standard. As an interim measure the BWC requires ships to manage their ballast water in accordance with Regulation D1.

4.1.3 Global response

Preventing the transfer of invasive species and coordinating a timely and effective response to invasions requires cooperation and collaboration among governments, economic sectors, nongovernmental organizations and international treaty organizations; the UN Convention on the Law of the Sea (Article 196) provides the global framework by requiring States to work together to prevent, reduce and control pollution of the marine environment including the intentional or accidental introduction of species, alien or new, to a particular part of the marine environment, which may cause significant and harmful changes thereto.

IMO has been at the front of the international effort by taking the lead in addressing the transfer of invasive aquatic species (IAS) through shipping. In 1991 the MEPC adopted the International Guidelines for preventing the introduction of unwanted aquatic organisms and pathogens from ships' ballast water and sediment discharges (resolution MEPC.50(31)); while the United Nations Conference on Environment and Development (UNCED), held in Rio de Janeiro in 1992, recognized the issue as a major international concern.

In November 1993, the IMO Assembly adopted resolution A.774(18) based on the 1991 Guidelines, requesting the MEPC and the MSC to keep the Guidelines under review with a view to developing internationally applicable, legally-binding provisions. While continuing its work towards the development of an international treaty, the Organization adopted, in November 1997, resolution A.868(20) - Guidelines for the control and management of ships' ballast water to minimize the transfer of harmful aquatic organisms and pathogens, inviting its Member States to use these new guidelines when addressing the issue of IAS.

After more than 14 years of complex negotiations between IMO Member States, the International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM Convention) was adopted by consensus at a Diplomatic Conference held at IMO Headquarters in London on 13 February 2004. In his opening address to the Conference the Secretary-General of IMO stated that the new Convention would represent a significant step towards protecting the marine environment for this and future generations. “Our duty to our children and their children cannot be over-stated. I am sure we would all wish them to inherit a world with clean, productive, safe and secure seas – and the outcome of this Conference, by staving off an increasingly serious threat, will be essential to ensuring this is so”.

Guidelines for the control and management of ships' ballast water to minimize the transfer of harmful aquatic organisms and pathogens

International Maritime Organization
The Convention requires all ships to implement a ballast water management plan. All ships have to carry a ballast water record book and are required to carry out ballast water management procedures to a given standard. Parties to the Convention are given the option to take additional measures which are subject to criteria set out in the Convention and to IMO guidelines.

Several articles and regulations of the BWM Convention refer to guidelines to be developed by the Organization and Conference resolution 1 invited IMO to develop these guidelines as a matter of urgency and adopt them as soon as practicable and, in any case, before the entry into force of the Convention, with a view to facilitate global and uniform implementation of the instrument.

The MEPC, at its fifty-first session in April 2004, approved a programme for the development of guidelines and procedures for uniform implementation of the BWM Convention, listed in Conference resolution 1, including additional guidance required but not listed in the resolution. The programme was further expanded at the fifty-third session of the MEPC in July 2005 to develop and adopt 14 sets of Guidelines, the last one being adopted by resolution MEPC.173(58) in October 2008. The Guidelines, some of which have been revised since their initial adoption, and a number of other relevant guidance documents can be accessed here.

4.1.4 Approval of ballast water management systems

During the Convention development process, considerable efforts were made to formulate appropriate standards for ballast water management. They are the ballast water exchange standard and the ballast water performance standard. Ships performing ballast water exchange shall do so with an efficiency of 95 per cent volumetric exchange of ballast water and ships using a ballast water management system (BWMS) shall meet a performance standard based on agreed numbers of organisms per unit of volume.

Regulation D-3 of the BWM Convention requires that ballast water management systems used to comply with the Convention must be approved by the Administration taking into account the Guidelines for approval of ballast water management systems (G8). The Guidelines (G8) have been revised in 2016 and converted into a mandatory Code for approval of ballast water management systems (BWMS Code), which was adopted by MEPC 72 (April 2018) and enters into force in October 2019.

Regulation D-3 also requires that ballast water management systems which make use of Active Substances to comply with the Convention shall be approved by IMO in accordance with the Procedure for approval of ballast water management systems that make use of Active Substances (G9). Procedure (G9) consists of a two-tier process – Basic and Final Approval – to ensure that the ballast water management system does not pose unreasonable risk to the environment, human health, property or resources.
A technical group of experts has been established under the auspices of GESAMP to review the proposals submitted for approval of ballast water management systems that make use of Active Substances. The GESAMP Ballast Water Working Group (GESAMP-BWWG) reports to the Organization on whether such a proposal presents unreasonable risks in accordance with the criteria specified in the Procedure (G9). For more detailed information regarding the ballast water treatment technologies please click here.

The Convention requires a review to be undertaken in order to determine whether appropriate technologies are available to achieve the standard. MEPC has conducted a number of such reviews and agreed that appropriate technologies are available to achieve the standard contained in regulation D-2 of the BWM Convention.

**4.1.5 BWM Convention status**

The Ballast Water Management Convention enters into force September 8th 2017, 12 months after the ratification of a minimum of 30 states, representing 35% of world shipping tonnage.

In a landmark step towards halting the spread of invasive aquatic species, the Convention will require all ships to implement a ballast water and sediments management plan which must include:

- A ballast water management system which adheres to the guidelines set out by the IMO. This might include:
  - filtration systems
  - chemical disinfection
  - ultra-violet treatment
  - deoxygenation treatment
  - thermal treatment (heat)
  - cavitation treatment (acoustic)
  - electric pulse systems
  - magnetic field treatment
- Duties of the personnel on board for carrying out ballast operations
- The operational procedure along with the method to be used for ballasting
- The locations where ballast water exchange is to be conducted
- The international rules and regulations for different port state controls all over the world
- The locations of ports providing shore discharge facilities of sediments and ballast water
- A ballast water exchange record book is to be kept and the following data is to be noted:
  - The date of the operation
  - The ship’s ballast tank used in the operation.
  - The temperature of the ballast water.
  - The salinity of the ballast water in PPM (salt content in parts per million).
  - The position of the ship (latitude and longitude).
  - The amount of ballast water involved in operation.
  - The date and identification of the tank last cleaned.
  - If there is accidental discharge of ballast exchange it must be entered and signed. Same information is to be given to concerned port state authority.
Ships constructed after September 8th 2017, must comply upon delivery, while existing ships must comply by their first International Oil Pollution Prevention (IOPP) certificate renewal after September 8th 2019. This will result in all ships belonging to nations having ratified the Convention, having a ballast water management plan in place by 2024.

“This is a truly significant milestone for the health of our planet. The spread of invasive species has been recognized as one of the greatest threats to the ecological and the economic well-being of the planet. These species are causing enormous damage to biodiversity and the valuable natural riches of the earth upon which we depend. Invasive species also cause direct and indirect health effects and the damage to the environment is often irreversible. The entry into force of the Ballast Water Management Convention will not only minimize the risk of invasions by alien species via ballast water, it will also provide a global level playing field for international shipping, providing clear and robust standards for the management of ballast water on ships.”

Kitach Lim, Secretary General of the International Maritime Organization

The adoption of all the required Guidelines for the uniform implementation of the BWM Convention and the approval and certification of modern ballast water treatment technologies have removed the major barriers to the ratification of the instrument and a number of additional countries have indicated their intention to accede to this Convention in the near future.

4.1.6 Amendments to the Convention 2018

At its seventy-second session in April 2018, MEPC adopted amendments to the Convention, which will enter into force in October 2019. The amendments are:

.1 amendments to regulations A-1 and D-3 of the BWM Convention to make the BWMS Code mandatory (resolution MEPC.296(72));

.2 amendments to regulation B-3 of the BWM Convention, concerning the implementation schedule of ballast water management for ships (resolution MEPC.297(72)), along with a resolution relating to the determination of the survey referred to in regulation B-3 (resolution MEPC.298(72)); and

.3 amendments to regulations E-1 and E-5 of the BWM Convention, concerning endorsements of additional surveys on the International Ballast Water Management Certificate (resolution MEPC.299(72)).

MEPC 72 also adopted the BWMS Code (resolution MEPC.300(72)), which will supersede the 2016 Guidelines for approval of ballast water management systems (G8) from October 2019.

Further amendments to the BWM Convention may occur now that the Convention is in force, including a possible comprehensive set of amendments after the ballast water experience-building phase (EBP) (resolution MEPC.290(71)). Taking into consideration

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14 Clear Seas, The Importance Of Ballast Water Management
that challenges may arise during the implementation of any new convention that were not
foreseen at the time of its adoption, the EBP was established by MEPC at its seventy-first
session in July 2017 as a means for carrying out a systematic and evidence-based review of
the BWM Convention.15

4.1.7 BWM Guidelines

Several articles and regulations of the Ballast Water Management Convention refer to
guidelines to be developed by the Organization and Conference resolution 1 invites IMO to
develop these guidelines as a matter of urgency and adopt them as soon as practicable, and in
any case before the entry into force of the Convention, with a view to facilitate global and
uniform implementation of the instrument.

In a commendable effort to facilitate the process, the IMO Member States have developed 14
sets of Guidelines from July 2005 to October 2008, some of which have since been further
revised. This outstanding and probably unique output in the working history of MEPC, would
have not been possible without the dedication of the BWWG and the technical support of the
BLG, FSI and DE Sub-Committees.

It should be noted that, due to the complexity and multi-disciplinary nature of the problem
posed by invasive aquatic species in ships' ballast water, the work is in its pioneering phase
and knowledge is only now gathering in this respect. The Guidelines are kept under review by
the MEPC and updated as new technologies emerge and additional knowledge becomes
available.

The following is the up-to-date list of Guidelines relating to the uniform implementation of
the BWM Convention that have been developed, adopted and, in some cases, revised since
MEPC 53:

- Guidelines for sediment reception facilities (G1) (resolution MEPC.152(55));
- Guidelines for ballast water sampling (G2) (resolution MEPC.173(58));
- Guidelines for ballast water management equivalent compliance (G3) (resolution
  MEPC.123(53));
- Guidelines for ballast water management and development of ballast water
  management plans (G4) (resolution MEPC.127(53));
- Guidelines for ballast water reception facilities (G5) (resolution MEPC.153(55));
- 2017 Guidelines for ballast water exchange (G6) (resolution MEPC.288(71));
- 2017 Guidelines for risk assessment under regulation A-4 of the BWM Convention
  (G7) (resolution MEPC.289(71));
- 2016 Guidelines for approval of ballast water management systems (G8)
  (resolution MEPC.279(70)) (this will be superseded by the BWMS Code
  (resolution.300(72)) in October 2019);
- Procedure for approval of ballast water management systems that make use of
  Active Substances (G9) (resolution MEPC.169(57));
- Guidelines for approval and oversight of prototype ballast water treatment technology
  programmes (G10) (resolution MEPC.140(54));
- Guidelines for ballast water exchange design and construction standards (G11)
  (resolution MEPC.149(55));

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15 IMO, BWM Convention and Guidelines
• 2012 Guidelines on design and construction to facilitate sediment control on ships (G12) (resolution MEPC.209(63));
• Guidelines for additional measures regarding ballast water management including emergency situations (G13) (resolution MEPC.161(56));
• Guidelines on designation of areas for ballast water exchange (G14) (resolution MEPC.151(55));
• Guidelines for ballast water exchange in the Antarctic treaty area (resolution MEPC.163(56)); and
• Guidelines for port State control under the BWM Convention (resolution MEPC.252(67)).

GUIDELINES AND GUIDANCE DOCUMENTS RELATED TO THE IMPLEMENTATION OF THE INTERNATIONAL CONVENTION FOR THE CONTROL AND MANAGEMENT OF SHIPS’ BALLAST WATER AND SEDIMENTS, 2004
**REGULATION D1 AND D2**

Regulation D1 requires ballast water carried by a ship during its voyage to be exchanged 3x their ballast tank volume to achieve at least a 95% volumetric exchange. Regulation D2 is a standard governing the treatment of ballast water at uptake to ensure that strict ballast water quality standards are met at the point of discharge.

*Implementation of the IMO convention*

The convention stipulates two standards for discharged ballast water. The D-1 standard covers ballast water exchange while the D-2 standard covers ballast water treatment. The convention requires either D-1 or D-2 standard after entry into force.

There will be a transitional period from the entry into force to the first IOPP renewal survey* after 8 September 2019 in which ballast water exchange (reg. D-1) can be employed. After the IOPP renewal survey, vessels will be required to meet the discharge standard D-2. The latter is most commonly met by installing an approved Ballast Water Management System (BWMS). Ships constructed** after entry into force will be required to have a treatment system installed at delivery.

*The renewal survey is the survey according to regulation E-1.2 of the BWM Convention, which is defined as the date of the renewal survey according to MARPOL Annex I, Reg. 6.2 (IOPP) by a separate resolution.

** Constructed means when: the keel is laid, construction identifiable with the specific ship begins, assembly of the ship has commenced comprising at least 50 tonnes or 1 percent of the estimated mass of all structural material, whichever is less, or the ship undergoes a major conversion.  

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16 DNVGL Maritime, Ballast Water Management
4.1.8 Ballast Water Treatment Systems

Under IMO’s “International Convention for the Control and Management of Ship’s Ballast Water and Sediments”, implementation of ballast water management plan and ballast water treatment system on board ships has thus become important.

In order to ensure their ships comply with the rules and regulations set by IMO regarding Ballast Water Management, several shipping operators have started implementing ballast water treatment systems on their ships.

A variety of technologies are available in the market for treating ballast water on ships. However, constraints such as availability of space, cost of implementation, and level of environmental friendliness play an important role in usage of a particular type of ballast water treatment system.

A number of factors are taken into account for choosing a ballast water treatment system for a ship. Some of the main factors taken into consideration are:

- Effectiveness on ballast water organisms
- Environment-friendliness
- Safety of the crew
- Cost effectiveness
- Ease of installation and operation
- Space availability on board
- Ship Deballasting
The main types of ballast water treatment technologies available in the market are:

- Filtration Systems (physical)
- Chemical Disinfection (oxidizing and non-oxidizing biocides)
- Ultra-violet treatment
- Deoxygenation treatment
- Heat (thermal treatment)
- Acoustic (cavitation treatment)
- Electric pulse/pulse plasma systems
- Magnetic Field Treatment

A typical ballast water treatment system on board ships use two or more technologies together to ensure that the treated ballast water is of IMO standards.

*Physical Separation/ Filtration Systems Ballast Water Treatments*

Physical separation or filtrations systems are used to separate marine organisms and suspended solid materials from the ballast water using sedimentation or surface filtration systems. The suspended/filtered solids and waste (backwashing) water from the filtration process is either discharged in the area from where the ballast is taken or further treated on board ships before discharging.

The following equipment are mainly used for ballast water filtration:

**Screens/Discs**: Screens (fixed or movable) or discs are used to effectively remove suspended solid particles from the ballast water with automatic backwashing. These are extremely environmentally friendly as they do not require usage of toxic chemicals in the ballast water. Screen filtration is effective for removing suspended solid particles of larger size but is not very handy in removing particles and organisms of smaller sizes.

*Note:* It has been noticed that though screens are highly effective in removing majority of suspended solid particles and organisms from ballast water, they alone are not sufficient to treat the ballast water according to IMO standards.

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![Screen Filters](image)
**Hydrocyclone**: Hydrocyclone is an effective equipment for separating suspended solids from the ballast water. High velocity centrifugal force is used to rotate the water to separate solids. As hydrocyclone doesn’t have a moving part, it is easy to install, operate and maintain on board ships.

*Note:* It has been found that as the operation of hydrocyclone heavily depends on the mass and density of the particle, they are not successful in removing smaller organisms from the ballast water.

![Hydrocyclone Diagram](image)

**Coagulation**: As most of the physical filtration methods are not able to remove smaller solid particles, the method of coagulation is used prior to the filtration process to join smaller particles together to increase their size. As the size of the particles increase, the efficiency during the above mentioned filtration processes increases. Such treatment involving coagulation of smaller particles into small flocs is known as flocculation. The flocs settle more quickly and can be removed easily.

*Note:* Some ballast water treatment systems using coagulation and flocculation utilize ancillary powder (sand, magnetite etc.) or coarse filters to produce flocs. An additional tank is required for treating ballast water for this process and thus extra space is required on board ships.
**Ballast Water Coagulation System**

**Media Filters**: Physical ballast water treatment systems with media filters can also be used in order to filter out smaller sized particles. It has been found that compressible media filters (Crumb rubber) are more suited for shipboard use because of their compact size and lower density as compared to conventional granular filtration systems.

**Magnetic Field Treatment**

The magnetic field treatment uses the coagulation technology. Magnetic powder is mixed with the coagulants and added to the ballast water. This leads to the formation of magnetic flocs which includes marine organisms. Magnetic Discs are used to separate these magnetic flocks from the water. (Refer the figure above)

**Chemical Disinfection (Oxidizing and non-oxidizing biocides) Ballast Water Treatments**

Biocides (Oxidizing and non-oxidizing) are disinfectants which have been tested to potentially remove invasive organisms from ballast water. Biocides removes or inactivates marine organisms in the ballast water. However, it is to note that the biocides used for ballast water disinfectant purpose must be effective on marine organisms and also readily degradable or removable to prevent discharge water from becoming toxic in nature.

On the basis of their functions, biocides are mainly divided into two types:

- Oxidizing
- Non-Oxidizing

**Oxidizing biocides**: Oxidizing biocides are general disinfectants such as chlorine, bromine, and iodine used to inactivate organisms in the ballast water. This type of disinfectants act by destroying organic structures of the microorganisms such as cell membrane or nucleic acids.
Some of the processes utilizing oxidizing biocides used on board ships are:

- Chlorination – Chlorine is diluted in water to destroy the micro-organisms
- Ozonation – Ozone gas is bubbled into the ballast water using an ozone generator. The ozone gas decomposes and reacts with other chemicals to kill organisms in the water.

Other oxidizing biocides such as chlorine dioxide, peracetic acid, and hydrogen peroxide are also used to kill organisms in the ballast water.

**Non-oxidizing biocides** : Non-oxidizing biocides are a type of disinfectants which when used interfere with reproductive, neural or metabolic functions of the organisms.

Though there are several non-oxidizing biocides available in the market, only a few such as Menadione/ Vitamin K are used in ballast water treatment system as they tend to produce toxic by-products. A lot of research is being made in this field to make more non-oxidizing biodes feasible for use in ballast treatment plant.

*Ultra-Violet Treatment Method*

Ultraviolet ballast water treatment method consists of UV lamps which surround a chamber through which the ballast water is allowed to pass. The UV lamps (Amalgam lamps) produce ultraviolet rays which acts on the DNA of the organisms and make them harmless and prevent their reproduction. This method has been successfully used globally for water filtration purpose and is effective against a broad range of organisms.

*De0xygenation*

As the name suggests, the deoxygenation ballast treatment method involves purging/removing of oxygen from the ballast water tanks to make the organisms asphyxiated. This is usually done by injecting nitrogen or any other inert gas in the space above the water level in the ballast tanks.

*Note:* It generally takes approximately 2-4 days for the inert gas to asphyxiate the organisms. Thus, this method is usually not suitable for ships having short transit time. Moreover, such
type of systems can be used on ships with perfectly sealed ballast tanks. If a ship is already installed with an inert gas system, then a deoxygenation system will not require more space on board ships.

*Heat Treatment*

This treatment involves heating the ballast water to reach a temperature that will kill the organisms. A separate heating system can be utilized to heat the ballast water in the tanks or the ballast water can be used to cool the ship’s engine, thus disinfecting the organisms from the heat acquired from the engine. However, such treatment can take a lot of time before the organisms become inactive and would also increase the corrosion in the tanks.

*Cavitation or Ultrasonic Treatment*

Ultrasonic energy is used to produce high energy ultrasound to kill the cells of the organisms in ballast water. Such high pressure ballast water cavitation techniques are generally used in combination with other systems.

*Electric Pulse / Plasma Treatment*

The electric pulse / plasma for ballast water treatment is still in the development stage. In this system, short bursts of energy are used to kill the organisms in ballast water.

In the pulse electric field technology, two metal electrodes are used to produce energy pulse in the ballast water at very high power density and pressure. This energy kills the organisms in the water.

In electric plasma technology, high energy pulse is supplied to a mechanism placed in the ballast water, generating a plasma arc and thus killing the organisms.

Both these methods are said to have almost the same effect on the organisms.

*A Typical Ballast Water Treatment System on Ships*

Most of the ballast water treatment system use 2-3 disinfectant methods together, divided into different stages. A general ballast water treatment plant comprises of two stages with one stage using physical separation while the second stage employing some disinfectant technology. The choice of treatment system used in combination depends on a variety of factors such as type of ship, space available on the ship, and cost limitations as mentioned before.

A typical ballast water treatment system on ships looks like this:
CHAPTER 5

Case of a Shipping Company on how she manages Environmental liability and the Ballast Water Management Systems issue

At this part of this dissertation we will find out how *Environmental liability and the Ballast Water Management Systems* are treated by Shipping Industry.

5.1 ENVIRONMENTAL POLICY

The Shipping Company is committed to the protection of the environment and to managing the environmental matters as an integral part of its business both ashore and at sea. In particular, it is MS policy to ensure the environmental integrity of its processes, equipment used and working environment at all times and at all places. The Shipping Company does so by adhering to the following principles:

- To recognize environmental management amongst the highest corporate priorities and as a key determinant to sustainable development;
- To establish policies, programs and practices for conducting operations in an environmentally sound manner;
- To comply with all applicable legal requirements, and with other requirements to which the MS subscribes. This is done by developing, implementing and maintaining processes, plans and procedures to ensure such compliance;
- To minimize any significant adverse environmental impact of new developments. This is done through the use of the environmental management procedures and...
planning, and through the assessment of environmental impacts, before starting a new activity or project;

- To develop and provide our services in such a way as to minimize their environmental impacts and improve their understanding at all stages by any of our customer and the international community, whilst ensuring they are safe for their intended use and efficient in their consumption of energy and natural resources;

- To develop environmental performance evaluation procedures and associated indicators, in order to measure the results of the Company’s management of its environmental aspects.

- Manage on business with the goal to prevent pollution, using processes, practices, techniques, materials, products, services or equivalent, to avoid, reduce or control the creation, emission or discharge of any type of pollutant or waste in order to reduce adverse environmental impacts, promoting always and achieving zero spill record. The prevention of pollution can include source reduction or elimination, process, product or service changes, efficient use of resources, material and energy conservation, reuse, recovery, recycling, reclamation and treatment.

- To educate, train and motivate employees to raise their awareness of the strategic importance of environmental management, encourage concern and respect for the environment so as to enhance their skills so that they can conduct their activities in an environmentally responsible manner;

- To communicate our commitment to environmental matters with all interested parties (employees, vendors, customers and any other person or group concerned with or affected by the environmental performance of the company), whilst sharing environmental experience, anticipating and responding to their concerns about potential hazards and impacts of operations, services or matters and encouraging the use of Environmental Management system by suppliers and contractors;

- To develop and maintain, where significant hazards exist, emergency preparedness plans in conjunction with the emergency services, relevant authorities and the local community aiming at responding quickly and effectively to incidents resulting from our operations;

- To continue to improve policies, programs and environmental performance, taking into account technical developments, scientific understanding, customer needs and community expectations, having always legal regulations as starting point;

- To make available this policy to the public.

5.2 Health, Safety & Environmental Management programmes

The Company has established safety, health and environmental management programmes for achieving effectively and efficiently its safety, quality & environmental, targets and requirements consistent with the strategy of the Company. These programmes include:

- Determination of skills and knowledge needed by the Company for the implementation of process improvement plans;
Designation of responsibility and authority for achieving the established objective and target at each level within the Company;

Resources needed, such as financial and infrastructure and time frame by which are to be achieved;

Metrics for evaluating the achievement of the Company’s performance improvement;

Needs for improvement including methods and tools;

and Needs for documentation, including records.

Health, safety & environmental programmes are developed to be responsive to the safety, quality and environmental policies and general planning activities.

The Company monitors the health, safety and environmental management programmes and, when necessary, revises them to ensure the effectiveness and efficiency of the Company’s processes.

Inputs for effective and efficient planning include, among others:

- Strategies of the Company;
- Defined Company’s objectives and targets;
- Defined needs and expectations of the customers and other interested parties;
- Evaluation of statutory and regulatory requirements;
- Evaluation of performance data of the vessels at terminals;
- Evaluation of performance data of the vessels and their staff by vetting inspectors and port State control officers;
- Lessons learnt from previous experience;
- Indicated opportunities for improvement; and
- Related risk assessment and mitigation data.

5.3 Related documentation

- Shore personnel job descriptions procedure (QP 03)
- Fleet Instruction Manual (Chapter 1)
- Emergency Management Plan
- Management review (QP 12.1)
- Control of Quality, Environmental & Safety Records (QP 13)
- Identification and Traceability Quality Procedure (QP 19)
- Company’s objectives and targets
- Action Plan for HSE Objectives and Targets (QP 23, QP 24)
- Reporting Accidents, Hazardous Situations & Customer Complaints Procedure (QP 07)

5.4 Fraudulent or Dishonest Conduct & Whistleblower Policy Statement

The Shipping Company will investigate any possible fraudulent or dishonest use or misuse of Company’s resources or property by management and staff. Anyone found to have been
engaged in a fraudulent or dishonest conduct is subject to disciplinary action up to and including civil or criminal prosecution when warranted.

All members of the Company are encouraged to report possible fraudulent or dishonest conduct (i.e. a whistleblower) and any employee should report his or her concerns.

No any employee of the Shipping Company who in good faith makes a report on a possible fraudulent or dishonest conduct shall suffer harassment, retaliation or adverse employment consequences. An employee that retaliates against someone who has made such a report in good faith is subject to discipline up to and including termination of employment.

**5.4.1 Definitions**

Baseless Allegations: allegations made with reckless disregard for their truth or falsity. People making such allegations may be subject to institutional disciplinary action and/or legal claims by individuals accused of such conduct.

Fraudulent or Dishonest Conduct: a deliberate act or failure to act with the intention of obtaining an unauthorized benefit. Examples of such conduct include, but are not limited to:

- forgery or alteration of documents
- unauthorized alteration or manipulation of computerized / electronic files fraudulent financial reporting
- misappropriation or misuse of Company’s resources, such as funds, supplies, or other assets
- authorizing or receiving compensation for goods not received or services not performed
- authorizing or receiving compensation for hours not worked

Whistleblower: an employee who informs the MD about an activity which that person believes to be fraudulent or dishonest.

**5.4.2 Rights and Responsibilities**

Managers or Superintendents

Managers or Superintendents are required to report suspected fraudulent or dishonest conduct to the MD. Failure by a manager or superintendent to report misconduct within the scope of this policy may result in adverse personnel action against the manager or supervisor, up to and including dismissal. Reasonable care should be taken in dealing with suspected misconduct to avoid:

- baseless allegations
- premature notice to persons suspected of misconduct and/or disclosure of suspected misconduct to others not involved with the investigation
- violations of a person's rights under law

Accordingly, a manager or superintendent faced with a suspected misconduct:
should not contact the person suspected to further investigate the matter or demand restitution
should not discuss the case with anyone other than the MD or a duly authorized law enforcement officer
should direct all inquiries from the media to the MD.

5.4.3 Whistleblower Protection

The Shipping Company will protect whistleblowers as defined below.

- The Shipping Company will use best efforts to protect whistleblowers against retaliation, as described below. The Shipping Company will keep the whistleblower's identity confidential, unless (1) the person agrees to be identified; (2) identification is necessary to allow The Shipping Company or law enforcement officials to investigate or respond effectively to the report; (3) identification is required by law; or (4) the person accused of Fraud Policy violations is entitled to the information as a matter of legal right in disciplinary proceedings.

- The Shipping Company employees may not retaliate against a whistleblower with the intent or effect of adversely affecting the terms or conditions of employment (including but not limited to, threats of physical harm, loss of job, punitive work assignments, or impact on salary or wages). Whistleblowers who believe that they have been retaliated against may file a written complaint with the MD. A proven complaint of retaliation shall result in a proper remedy for the person harmed and the initiation of disciplinary action, up to and including dismissal, against the retaliating person. This protection from retaliation is not intended to prohibit managers or superintendents from taking action, including disciplinary action, in the usual scope of their duties and based on valid performance-related factors.

- Whistleblowers must be cautious to avoid baseless allegations

5.5 HEALTH, SAFETY & ENVIRONMENTAL MANAGEMENT SYSTEM

5.5.1 Managing Systems and Processes

The top management of the Company operates the Company in a systematic and visible manner. The aim of top management is to establish a customer – oriented organization:

a. by defining systems and processes that can be clearly understood, managed and improved in effectiveness as well as efficiency; and

b. by ensuring an effective and efficient operation and control of the processes and the measures and data used to determine satisfactory performance of the Company.

To achieve this goal the top management has been:

- defining and promoting processes that lead to improved organizational performance;
acquiring and using process data and information on a continuing basis;
- directing progress towards continual improvement; and
- using suitable methods to evaluate process improvement such as self-assessments and management review.

5.5.2 Documentation Structure

5.5.2.1 General
The nature and extent of the documentation is such as to satisfy the contractual, statutory and regulatory requirements, and the needs and expectations of customers and other interested parties and to be appropriate to the Company and the managed ships.

5.5.2.2 Outline
The documentation of the HSE Management System consists of:

- The Health, Safety & Environmental Management System Policy Manual
- Health, Safety & Environmental Procedures (Quality Procedures)
- Instructions and supporting material:
  - Fleet Instructions Manual
  - Circulars
  - Letters
  - Alerts
  - Cargo Operation & Handling Manuals
  - Forms & Checklists ⇒ Emergency Management Plan
  - SOPEP & VRP / CAVRP ⇒ SOLAS Vessel training manuals
  - Fire Training Manual
  - Garbage Management Plan
  - Ballast Water Management Plan
  - Refrigerant Management Plan
  - Bilge & Engine Room Oily Waste Management Plan
  - Plan & Procedures for Recovery of Persons from Water
  - Sewage Management Plan
  - Planned Maintenance System

5.5.2.3 Health, Safety & Environmental Management System Policy Manual
The Health, Safety & Environmental Management System Policy Manual is available to all Company employees and selected Company customers and:

- Outlines the HSEM system (“what” The Shipping Company does as regards quality of service, safety and environmental protection);
- States the Company’s policies and associated principles;
- Defines the scope of application of the Management System;
- Defines the management system’s organization and provides brief descriptions of responsibility and authority of the key management personnel / departments. Addresses the requirements of the ISM Code.
- Makes reference to the associated system procedures.

5.5.3 Health, Safety & Environmental Procedures (Quality Procedures)
They describe “how” the Shipping Company accomplishes its activities in the functional areas addressed in the HSE Management System, assign responsibility and identify relevant records.

System procedures include:

- Procedures for the preparation of plans and instructions for activities affecting safety, pollution prevention and quality of service;
- Procedures for reporting incidents and non-conformities;
- Procedures for preparing for and responding to emergency situations;
- Procedures for internal audits, management reviews and applying corrective and preventive actions;
- Procedures for shipboard maintenance of ship and equipment;
- Procedures for document control and maintenance of records;
- Procedures to ensure provision of qualified personnel for the various tasks involved in the key operations ashore and onboard;
- Procedure related with Company’s safety, health and environmental aspects, objectives and targets and respective programmes;
- Procedures for risk assessment and management; and
- Procedures to ensure compliance with fiduciary requirements, where required by the ship management agreements.

5.5.4 Control of Health, Safety & Environmental Records
Records are established and maintained to provide evidence of conformity to specified requirements and of the effective operation of the HSEM system as well as for recording the extent to which planned objectives and targets have been met.

Health, safety and environmental records may include:

- Information on applicable safety, health and environmental laws or other requirements;
- Complaint records;
- Training records;
- Process information;
- Inspection, maintenance and calibration records;
- Pertinent contractor and supplier information;
- Incident reports;
5.5.5 ENVIRONMENTAL ASPECTS & IMPACTS

The Shipping Company has established, implemented and maintained a procedure to identify the environmental aspects of its activities, products and services within the environmental scope of the environmental management system that it can control and it can influence and to determine those aspects that have or can have significant impacts on the environment. This procedure takes into account:

- The cost and time of undertaking the analysis;
- The availability of reliable data;
- The information already developed for regulatory purposes; and
- The degree of practical control and influence that the Company may have over the environmental aspects being considered and planned, or new developments or new or modified activities, products and services.

The determination of the Shipping Company’s environmental aspects is carried out taking into account the inputs and outputs associated with its current and relevant past and future activities transported products and services.

The initial identification of the environmental aspects is carried out after a thorough review of the following four key areas:

a) Legal and other requirements;

b) An examination of all existing environmental management practices and procedures;

c) An evaluation of feedback from the investigation of previous incidents and
d) An evaluation of future activities and services.

In all cases consideration is given to normal and abnormal operations on board and to potential emergency condition. The process to identify the significant environmental aspects, considers both Company’s shipboard and shore based activities. In addition to those environmental aspects, that the Company can control directly, the Company considers also aspects that it can influence, such as:

- Packaging and transportation of supplies used by the Company; and
- Environmental performance and practices of contractor and suppliers.

Associated with each identified environmental aspect, as many as possible actual and potential, positive and negative environmental impacts are identified by the Environmental Team, consisting of the Managing Director, the DPA, the HSE Manager and the Technical Manager.

For determining the significance of each of the identified environmental impacts, an evaluation is carried out by considering:

a) Environmental concerns like as:
   - The scale of the impact;
   - The severity of the impact;
   - Probability of occurrence; and
   - Duration of impact

b) Business concerns, such as:
   - Potential regulatory and legal exposure;
   - Difficulty of changing the impact;
   - Cost of changing the impact; and
   - Concerns of interested parties

5.6 Monitoring and Measurement of Health, Safety and Environmental Performance

The company has established, implemented and maintained a systematic approach for monitoring and measuring its safety, quality and environmental performance, on a regular basis. This systematic approach involves collection and evaluation of information related to the key operations of the company’s activities. Measurements can be either quantitative or qualitative. Monitoring and measurements can serve many purposes in the company’s management system, such as:

- Tracking progress on meeting the company’s policy commitments, achieving its objectives and targets and continual improvement
- Developing information to identify significant safety and environmental aspects
- Monitoring emissions and discharges to meet relevant Company’s objectives and targets as well as applicable legal and other requirements to which the company subscribes.
- Monitoring the effectiveness of accidents’ prevention measures selected to meet the Company’s objectives and targets and continual improvement.
- Monitoring the fleet vessels operational performance in respect to the company’s objectives and targets and expectations of third interested parties.
- Providing data to evaluate operational controls
- Providing data to evaluate company’s safety, health and environmental performance
- Providing data to evaluate the effectiveness of the company’s management system

To achieve the above purposes the company regularly plans what will be measured where and when it should be measured and what methods should be used.

The results of measurement and monitoring are regularly reviewed, analysed and used to identify both successes and areas requiring correction or improvement.

5.6.1 Measurement and Monitoring of Customer Satisfaction

Measurement and monitoring of customer satisfaction is based on review of customer-related information. The collection of such information is both active and/or passive. Management recognizes that there are many sources of customer-related information and for this reason continuously establishes effective and efficient processes to collect, analyze and use this information with the aim of improving the performance of the Company. The Company has identified sources of customer information using internal and external sources. Example of internal sources is the direct communication of the responsible persons in the Company with various departments of charterers or with various terminals. The external sources through which the Shipping Company may receive customer-related information are, without being limited to:

- Agents
- INTERCARGO
- INTERNET
- Other shipping companies
- Classification societies

Examples of customer-related information include:

- Third parties inspections
- Charter parties and voyage orders information
- Market needs Letter of protests and/or claims
- Charterers performance records
- Company’s management review meetings
- Audits’ results

MS’s management uses measurement of customer satisfaction as a vital tool. The Company’s developed process for requesting, measuring and monitoring feedback of customer satisfaction provides information on a continual basis. The objective of the relevant developed
procedure is the conformity to the applicable requirements, meeting needs and expectations of customers, as well as the fixing of fleet vessels to a competitive freight.

The Company has developed and established processes to listen effectively and efficiently to the “voice of the customer”. These processes define and implement data-collection methods, including information sources, frequency of collection and data – analysis review.

Sources of information on customer satisfaction include but are not limited to:

- Customer complaints
- Communicating with customers through brokers channel
- Meetings with charterers
- Terminal reports and feedbacks

The Companies who have an environmental aspect have a procedure in order to comply with all the regulations.

5.7 Purpose

The purpose of the procedure is to define the controls and activities necessary to identify and maintain the environmental aspects of the Company’s activities, both ashore and onboard, in order to:

- determine and re-evaluate those that may have a significant impact on the environment
- ensure that the significant environmental impacts have been considered in setting company’s objectives and targets.

5.7.1 SCOPE

The procedures is addressed to those environmental aspects of activities, both ashore and onboard, that the company can control and over which it can be expected to have an influence.

5.7.2 REFERENCES

- Environmental Objectives, Targets & Programmes manual
- F.I.M. 7
- Ballast Management Plan
- Garbage Management Plan
- Bilge & ER Oily Waste Management Plan
- Sewage Management Plan
- VOC Management Plan
- QP 12.1
- QP 23
5.7.3 RESPONSIBILITIES

The Environmental Management Representative is responsible to identify & assess environmental aspects & impacts of existing & new Company’s activities both ashore and onboard.

The EMR shall implement the MoC and/or MRM procedure as applicable, for ensuring all identified environmental aspects have been taken into account & incorporated in HSQEEn Management System.

5.7.4 Definitions

**Activity:** Any type of work or task related to Company’s systems and their operation, land based or shipboard based.

**Environmental aspects:** Element of the Company’s activities and services that can interact with the environment.

**Environmental impact:** Any change to the environment, whether adverse or beneficial, wholly or partially resulting from the company’s environmental aspects.

**Environment:** Surroundings, in which an organization operates, including air, water, land, natural resources, flora, fauna, humans and their interrelationships.

**Environmental condition:** state or characteristic of the environment as determined at a certain point in time environmental

**Organization:** person or group of people that has its own functions with responsibilities, authorities and relationships to achieve its objectives.

**Interested party:** person or organization that can affect, be affected by, or perceive itself to be affected by a decision or activity

**Prevention of pollution:** use of processes, practices, techniques, materials, products, services or energy to avoid, reduce or control (separately or in combination) the creation, emission or discharge of any type of pollutant or waste, in order to reduce adverse environmental impacts.

**Significant Aspect:** An environment aspect which has or can have a significant environmental impact.

**Significant Impact:** The impact’s significance of each aspect shall be determined through a risk assessment methodology and analysis, taking into consideration the frequency and the severity of each one. In case the result of impact’s risk assessment is moderate or higher, then it shall be characterized as significant and will be relevantly dealt with.

**Environmental performance:** performance related to the management of environmental aspects.
5.7.5 Significance Evaluation

5.8 Ballast Water Treatment System
The Shipping Company has decided to use as treatment Systems, OCEANSAVER MK II, which is an Electro Chlorination & filter type of ballast system.
The filters are the first treatment step in the OS BWTS.

Ocean Saver has been approved with two different filter makers, MH and FS.

The have the same basic working principle being automatic backflushing filters with sintered filter screens.

Water from the ballast pumps are pumped into the filter and all organisms and particles larger than the openings in the filter screen will be stopped by the filter screen. As more and more organisms is stopped the pressure loss over the filter screen will increase. When the pressure drop reaches a pre-set level (0.4-0.5 bar) the filter will automatically initiate a flush sequence.

During the backflushing operation, the entire area of the screen is cleaned by the internal suction nozzles. The backwash flow (sludge) will then exit through the open flushoutlet valve and pumped overboard. The filter does not need to be taken offline during a backflush and the BWTS will operate as normal during the filter cleaning.

Inside the filter a multilayer screen made in 316L and with a nominal rating of 40 µm they ensures high efficiency removal of large organisms. The screen has is specifically designed for BWTS purpose and can handle high amounts of TSS (Total Suspended Solids) without reduction in flow.

The filter is controlled by a standalone PLC that communicates directly with OS automation system.

When installed in gas hazardous zones the all the electrical components will have the necessary ex certificates.
The disinfectant unit is developed by OS and has several patents covering the key functionality of the unit.

The purpose of the C2E is to produce oxidants from seawater to eliminate organisms not removed by the filter(s). It does so by generating strong oxidants in the electrolytic membrane cell.

The C2E requires a feed water supply of approximately 1 % of the BW flow, which is fed by a separate pipe loop from the sea chest or from a BW intake line. If the salinity in the surrounding water is too low, lower than 20 PSU, the system must use an onboard tank filled with high salinity water as source for the feed water.

The C2E is skid-based and consists of several sub-components.

The C2E comes in three different size families; Small, Medium and Large. The total treatment capacity of the C2E(s) is scaled according to the capacity of the BW pumps. Capacity range from 200 m³/h to 7500 m³/h from a single skid.

**The cell:**

The main component of the C2E is an electrolytic cell where a membrane separates the anode and cathode chambers. The separating membrane allows for ionic exchange and ensures against flow exchange between the anolyte and the catholyte. The concentrated oxidants are produced at the anode side. On the cathode side H₂ gas and caustic water is produced as the main by-products of the process. To meet necessary flow-rates and production capacities, the cell is modularly designed and consists of a number cell pairs arranged in series.

**The rectifier:**

The C2E skid internal rectifier unit has its 440V Alternating Current (AC) operational power supplied through the C2E power distribution unit (EL 992). The rectifier unit converts the AC power to a 50V (maximum) Direct Current (DC) power with the necessary current magnitude to operate the cell. The rectifying unit is cooled with water supplied to the skid from the vessel. OS is currently using two different types of rectifying units depending on capacity. The rectifier is controlled via the skid internal interface cabinet (EL993). Typical control signals are rectifier on/off and start/stop. The rectifier is also remotely controlled by a dedicated control software application via the internal interface cabinet.

**Gas separation:**

One of the by-products from the oxidant production is H₂ gas. For safety reasons, the highly explosive H₂ gas must be separated from the catholyte and disposed of. The amount of H₂ gas generated is a function of applied electric current to the cell, which again is dependent on the organic load in the water to be treated. Gas separation and removal capacity is dimensioned according to the maximum production rate under worst case water conditions and follow class requirements. As a standard solution OS offers a two-phase separator as part
of the C2E skid. After separation, the H2 gas needs to be disposed of. The standard OS solution is to dilute the separated H2 gas into a ventilation duct exposed to forced ventilation.

**Piping etc:**

The piping used on the disinfectant unit is PVC because of its excellent resistance against strong oxidants. All the valves on the skid are also in PVC and come with pneumatic actuators. Flow meters, pressure transmitters and levels sensors are used to control the on-skid process.

**Cabinets & SW:**

The disinfectant unit is a standalone unit with its own PLC and control system. There are two cabinets on the skid, one for power distribution and one for signal interface.

![TRO Monitor](image)

**TRO Monitor**

Measures TRO concentration
Continuous monitoring during ballast and de-ballast
DPD (N,N-diethyl-p-phenylenediamine) spectroscopic detection
Ex proof version available

The disinfectant levels are continuously monitored during ballasting to ensure the correct disinfection dosage levels and during discharge to ensure compliance with the discharge limits. In the OS MKII BWTS, the TRO levels are detected at three different sample points in the process. One sampling point is used during uptake and the other two during discharge. Samples from the respective sample points are analysed by use of a single TRO monitor. Dedicated valves are automatically operated to provide samples from the different sampling points according to operational sequence engaged at any time. Ships draft and ballast tank sounding levels will have an impact on pressure from the sample points. To stabilize and ensure sufficient flow to the TRO monitor, a TRO sample pump is installed.

The monitor used in the OS BWTS MKII is a TRO monitor of the DPD (N,N-diethyl-p-phenylenediamine) type. An image of the TRO monitor can be found in Figure 7. In Table 8 the main components of the monitor are listed. The DPD method is based on spectroscopic
detection of the red colour reaction between TRO and an added DPD chemical. The intensity of the resulting colour depends on the TRO concentration in the water. Based on this the system provides a numerical reading.

The Ex version of the TRO monitor can be installed in pump room. Protection type Pressurized.

The TRO-N unit ensures neutralization of TRO if the TRO level exceeds maximum allowable discharge limits. This would typically be the case during discharge after short voyages where the water has not been stored long enough for the natural decay of TRO to be completed. Neutralization can be engaged either manually or automatically based on a pre-set discharge limit.

The maximum allowable discharge level set by IMO is 0.2 mg/l. Levels set by the Environmental Protection Agency (EPA) in the Vessel General Permit (VGP) for US waters are 0.1 mg/l. Other limits may apply according to local, regional or national regulations. Automatic neutralization may be programmed to activate at any given level. If lower limits apply at a given port, neutralization may be engaged manually.

The OS BWTS MKII applies Sodium Thiosulphate Pentahydrate (STP) or Sodium Thiosulphate anhydrous (STA) as the neutralizing agent. This is non-toxic and has a long shelf life. Further information about STP/STA can be found in the MSDS and in section 2.3.1. It is diluted with non-chlorinated potable water into the dosing tank. The tank is equipped with an agitator to ensure that the STP/STA granules are dissolved and that the solution is mixed evenly. One or two dosage pumps (depending upon model) manage the feed of the diluted STP/STA solution to the point(s) of injection. An illustration of the TRO-N unit is provided in Figure 8. Main components are listed in Table 9.

**Heater**

Heating of electrolyte to improve efficiency of oxidant production

Installed in C2E feed loop

Waste heat or Steam as heat source

Optimized power consumption
The efficiency of the oxidant production and hence the power consumption of the C2E is temperature dependent. The temperature of the feed water to the anolyte compartment of the membrane cell on the C2E skid should not be below the temperature specified for the particular C2E model. Different heat sources can be used. OS supplies as a standard solution a heat exchanger for steam or hot waste water (on hot side) and seawater (cold side). The heater will always be powered and in standby, but will not start before the feed water from the sea chest or APT is below the specified temperature.

Salinity sensor on C2E feed water. If the salinity falls below 20 PSU, the feed water is automatically taken from an alternative high salinity storage tank.

Flowmeters on main BW lines: For dosage control and to control the FCV. To correct for the dilution effect when calculating which dosage to inject.

Flowmeters on anolyte line: Only included in cases where one C2E is used to serve two separate BW lines. To correctly distribute the injection of anolyte between the two BW lines.

Pressure transmitters upstream and downstream the two main filters, the APT filter (where applicable) and the C2E feed filter.

To ensure sufficient pressure for filter flushing and to monitor differential pressure across filter.

Pressure transmitters in front of FCV.

To control the FCV.

Pressure transmitter upstream of C2E.

Reference pressure for frequency converter on C2E feed pump.

The FCV has two functions. It is used to ensure that the BWTS operates against a set minimum pressure. This is done to compensate for variation in flow and pressure in the main BW line as the ships ballast tanks are filled. This is necessary to maintain optimal filter function and flow control. The second function is for dosage control in circumstances were required TRO levels cannot be reached at the maximum C2E power settings. The flow is then reduced to a level were the required concentration can be supplied.
**Operational benefits**

- Fully automated system meaning less crew training
- Low maintenance
- Less consumables
- Suitable for all water conditions
- Safe and easy to operate
- Standalone control system with monitoring of essential valves in ballast system
- Automatic controlling all processes in OS BWTS
- Simple and efficient – leading crew through all necessary steps of operation
- Generates IMO report during ballast / de-ballast operation

### 5.9. CONCLUSION

Ballast waste management is a serious maritime issue. It poses serious ecological, economical and public health concerns for host eco-systems and countries where these waste are deposited. As a result, it is crucial that such waste are disposed of and processed properly. Based on extensive research, it is apparent that the current legislations and policies in place are not being enforced appropriately, which leaves the system still open to abuse, and as a result, public health concerns are not being addressed.

The IMO ballast water convention is on the verge of getting ratified. The sudden change in ballast water operational practice in 2017, will result in the shipping industry needing to adjust their vessels to meet the new requirements by installing a treatment system. At present, there is limited knowledge and experience in the industry in relation to installing and using treatment technology for ballast water. Therefore, a huge step has been done and from now we expect all shipping companies to revert their policy in order to comply with the international regulations.
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