ISSN: 2414-1895 DOI: 10.6919/ICJE.202204_8(4).0082

Requirements for Ship Ballast Water Control and Management and Application Status of Ballast Water Treatment Technology

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Abstract

With the rapid development of international trade and shipping technology, harmful aquatic organisms and pathogens contained in ballast water have increasingly become a major threat to global environmental and resource security and human health. MARPOL Convention is introduced, the evolution of the Convention with years, and the requirements for the control and management of ship ballast water are put forward. In addition, with the increasing attention to the ecological problems caused by the invasion of alien species brought by ballast water, ship ballast water treatment technology has been focused and developed by relevant industries and scholars at home and abroad, ballast Water treatment technology is also developing. This paper studies the treatment technology of ship ballast water at home and abroad, and analyzes its present situation.

Keywords

MARPOL Convention; Ship Ballast Water; Control and Management; Processing Technology.

1. Introduction

With the development of economic globalization, the shipping industry, which is an important bridge connecting all countries in the world, has also developed rapidly, and a large number of goods are transported to all parts of the world through ships. In order to ensure the safe navigation of the ship, it is necessary to add ballast water. Ship ballast water mainly refers to the water and suspended matter added to the ship for the purpose of controlling the ship's heel, trim, draught, stability or stress. For ship ballast water, it contains a large number of organisms, including plankton, microorganisms, bacteria and even small fish and eggs, larvae or spores of various species, some of these organisms will follow the ship in the process of sailing. Some die because they cannot adapt to changes in temperature, salinity, etc., while some survive and eventually discharge into a new environment with the ship's ballast water. The injection and discharge of ballast water will lead to the spread of invasive phytoplankton and pathogenic microorganisms, causing the invasion of alien organisms, destroying the local ecosystem, endangering the local natural environment and economic development, and threatening public health. For the foreseeable long-term impact, it is estimated that about 10 billion tons of ship ballast water is transferred every year, and about 7,000 to 10,000 species of marine microorganisms are transported to different sea areas around the world with the ballast water every day (IMO.2017). It is easy to cause harm such as engulfing native species, changing habitats, changing environmental conditions, changing food chains, affecting ecological structures, competing with native organisms for food and living space, replacing native organisms, and reducing native biodiversity.

In this way, organisms in one water area will grow and reproduce as the ship sails into another water area, which will have a greater impact on the hydrological ecology of the corresponding area, that is,

ISSN: 2414-1895 DOI: 10.6919/ICJE.202204_8(4).0082

the surrounding environment, and even lead to the extinction of species in the corresponding area in severe cases. For example, in the Great Lakes region of the United States, the U.S. government spends more than $100 million a year to control the continuous breeding of zebra beetles due to the problem of blockage of drainage pipes caused by the large breeding of European zebra beetles. Another example is the dinoflagellate toxin, which can cause paralysis or even death in the human body. It can be absorbed by filter-feeding shellfish such as oysters, and its toxin is being absorbed by the human body through oysters (General Administration of Quality Supervision, Inspection and Quarantine). The fundamental reason for the invasion of alien marine organisms lies in the massive transfer and discharge of ship ballast water worldwide. Since the 1980s, governments and organizations have been actively responding to them by conducting research on legislation, management and technology. It can be seen from this that shipboard ballast water has a very high risk and is currently listed as one of the four major threats to the ocean by the Global Environment Fund, which needs to be dealt with in a timely and thorough manner.

2. MARPOL Convention

2.1 Significance of the MARPOL Convention

The International Convention for the Control and Management of Ships' Ballast Water and Sediments, opened on 1 June 2004, provides internationally legally binding regulations for global ballast water management and control. The Convention aims to inhibit the spread of harmful microorganisms and pathogens through the control and management of ships' ballast water and sediments, reduce the consumption of environmental resources, harm to human health, and the loss of property resources. International Convention on Ballast Water Carrying Alien Species Invading the Ocean and Destroying the Marine Ecological Environment. The convention requires some new ships built in 2009 to meet biological and sanitary standards for onboard ballast water treatment, and all ships to meet these standards by 2016. According to the provisions of the entry into force of the Convention, the Convention will enter into force 12 months after ratification by at least 30 countries that collectively not less than 35% of the gross tonnage of the world's merchant ships. At present, 16 countries and regions have ratified the convention, but it will take several years before it enters into force.

Joining the Ballast Water Convention will help protect the ecological environment of my country's seas and ensure the healthy and sustainable development of the shipping industry. The Ministry of Transport, together with the Ministry of Industry and Information Technology and other units, organized Hebei Maritime Safety Administration, China Shipbuilding Industry Association, China Shipowners Association, China Classification Society, etc. to compile and implement guidelines, carry out publicity and training, strengthen the connection between production and demand, and further guide domestic shipbuilding , supporting enterprises and shipping enterprises to do a good job in the full implementation of the "Ballast Water Convention". With my country's accession to the Ballast Water Convention, my country can carry out port state supervision and inspection of ballast water and PSC inspections on foreign ships berthing at Chinese ports, which reflects China's protection of the marine ecological environment and promotes green, sustainable shipping industry. Commitment to environmental sustainability. As a large port gathering place in my country, the implementation and promotion of ballast water monitoring and management and the implementation of PSC inspections in the Bohai Sea will help restore and improve the marine ecological environment of the Bohai Sea and promote the green and sustainable economic development of the Bohai Rim region. As the largest offshore operator in China, CNOOC adheres to the development concept of "innovative, coordinated, green, open, and shared", and will actively cooperate with relevant departments to promote the implementation of the Ballast Water Convention and strive to contribute Chinese wisdom. Under the background of the gradual implementation of the "Ballast Water Convention", the ballast water treatment system has achieved rapid development, and ballast water treatment equipment with different principles, functions and types has been widely used in ocean-going ships..

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2.2 History of the MARPOL Convention

The International Maritime Organization (IMO) has attached great importance to the marine environmental problems caused by ship ballast water. Since the early 1980s, it has included the solution of ship ballast water problems into the agenda of its Marine Environmental Protection Committee (MEPC), and successively formulated A number of conventions, guidance documents and resolutions of the General Assembly have been formulated to guide the control and management of ships' ballast water, such as: the 1982 United Nations Convention on the Law of the Sea; Guidelines on Biological Diversity; 1992 Convention on Biological Diversity; 1993 IMO Resolution A.774(18), which prioritizes addressing the spread of harmful aquatic organisms and pathogens; 15 September 1995, IMO Marine Environment Protection Committee Resolution MEPC.67(37); 1997 Guidelines for the Control and Management of Ships' Ballast Water to Reduce the Spread of Harmful Aquatic Organisms and Pathogens; 1998, Threats to Ecosystems, Habitats and Species by Alien Species; 1999 In 2004, IMO, the United Nations Development Programme (UNDP) and the Global Environmental Protection Fund (GEF) jointly implemented the Ballast Water Management Plan (Glo Ballast), which has now entered the second phase of the project; February 13, 2004 , the Diplomatic Conference of IMO member states adopted a landmark independent convention - the "International Convention on the Control and Management of Ships' Ballast Water and Sediments". As of 2008, MEPC has successively adopted all 14 technical guidelines of the Convention in the form of resolutions.

The International Maritime Organization (IMO) adopted the International Convention on the Control and Management of Ships' Ballast Water and Sediments, 2004 (referred to as the "Ballast Water Convention") in London, UK on February 11, 2004, and in September 2017 It officially entered into force on January 8. In October 2018, my country submitted an instrument to IMO to join the Ballast Water Convention. The Convention officially entered into force for my country on January 22, 2019 (IMO. ,2004).

2.3 Requirements of MARPOL Convention for Ship Ballast Water Control and Management

In 2004, the International Maritime Organization adopted the "International Convention on the Control and Management of Ship Ballast Water and Its Sediments" at the International Ship Ballast Water Management Conference, emphasizing the comprehensive control of ship ballast water, and proposed ballast water Requirements for replacement standards, biological and sanitary standards for ballast water treatment, etc. Under the guidance and management of the convention, research on ship ballast water treatment has been carried out at home and abroad, and a variety of effective methods have been formed. The Ballast Water Convention can only enter into force if the following three conditions are met (General Administration of Quality Supervision, Inspection and Quarantine):

(1) At least 30 countries have ratified, accepted, approved or acceded to the Convention;

(2) The total merchant fleet shall not be less than 35% of the gross tonnage of the world's merchant ships;

(3) Twelve months from the date when the first two conditions are met.

The Ballast Water Convention establishes D-1 (replacement standard) and D-2 (discharge standard) ballast water management standards.

D-1 Replacement standard: ① For ships carrying out ballast water replacement, the volume replacement rate shall be at least 95%; ② For ships with pump-through method (overflow method and dilution method) for ballast water replacement, each ballast water tank shall be pumped The water volume that flows three times the tank capacity is considered to meet the requirements; ③ If the pumped water volume is less than three times the volume of the ballast tank, but it can be proved that a replacement rate of > 95% is achieved, it can also be accepted. Ships carrying out ballast water replacement shall carry out ballast water replacement at a distance of ≥364 km from the nearest land and a water depth of ≥200 m; when the ship cannot perform ballast water replacement according to the above requirements, it shall be ≥91 km away from the nearest land as far as possible. Ballast water replacement shall be carried out in places with a depth of 200 m or more. If the above two

ISSN: 2414-1895 DOI: 10.6919/ICJE.202204_8(4).0082

requirements are not met, the port state may designate an area for ships to carry out ballast water replacement. When a ship is required to perform ballast water replacement but fails to perform it, the reasons for not performing ballast water replacement shall be recorded in the Ballast Water Record Book.

D-2 Discharge Standard: ① Plankton ≥ 50 μm shall not exceed 10 cells/m3; ② Plankton of 10~50 μm shall not exceed 10 cells/m3; ③ Index microorganisms shall not exceed the specified concentration; ④ Prototype ballast water treatment technology shall be used ships within 5 years from the date on which the D-2 standard applies to the ship.

2.4 Countermeasures for Chinese Ship Ballast Water Control and Management

My country attaches great importance to the control of ballast water pollution, and is one of the first six implementation countries selected by the IMO organization, UNDP (United Nations Development Program) and GEF (Global Environmental Fund) as the first phase of the global ballast water management plan. Dalian Port is a demonstration site in my country, and Liaoning Maritime Safety Administration is a member of the China Project Implementation Team of the project. At present, my country has established a national project implementation steering group participated by the Ministry of Transport, the State Environmental Protection Administration, the State Oceanic Administration, the Ministry of Agriculture and other relevant departments. The development of the device, and the establishment of the information reporting system for the red tide occurrence area of ships sailing, etc. In 2006, CCS classification society also issued the "Guidelines for the Preparation of Ship Ballast Water Management Plans". However, as a large maritime country with a long coastline and numerous ports, my country still lags far behind European and American countries in the management and control of ballast water. So far, my country has not established an effective supervision and management system, and has not formed ballast water management, especially there are no regulations to solve the problem of ballast water transfer alien organisms to protect the fragile marine ecological environment, only to deal with infectious diseases and epidemics. Quarantine control of ships in the area and some port authorities require ballast water discharge applications.

3. Ship Ballast Water Treatment Technology

The effective treatment of ship ballast water is an important means to ensure the stability of the marine ecological environment of various countries. Currently, the commonly used treatment technologies include physical treatment technology, chemical treatment technology, mechanical treatment technology, replacement of ship ballast water, and heating electrolysis. At the same time, relevant enterprises and scholars at home and abroad have actively carried out the development and research of ship ballast water treatment system, and achieved good results. Especially the heating electrolysis method proposed in my country. At the same time, relevant enterprises and scholars at home and abroad have actively carried out the development and research of ship ballast water treatment system, and achieved good results. In particular, the heating electrolysis method proposed by my country has obtained international certification, which has promoted the improvement of the international influence of my country's shipbuilding industry (Liu Mingjie,2007).

3.1 Physical Processing Technology

Physical methods include heating method, ultrasonic method, ultraviolet method, etc. Heating method refers to the use of steam, marine engine waste heat and other means to heat the ballast water, which has a certain impact on the organic matter in the water. UV treatment will not produce secondary pollution, but will not kill all harmful organisms. Combined with the filtering method, this method is effective.

3.1.1 Heat Treatment Method

Under the condition of 40-45 ℃, the inactivation of harmful organisms in the ship's ballast water can be completed, and the inactivation effect of low temperature and longtime treatment is better than that of high temperature and short time treatment. Under the condition of 38-50 ℃, maintaining the

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corresponding temperature for 2-4 hours can realize the inactivation of most organisms in the ship's ballast water. However, if the organisms exist in the form of dormant spores, the treatment temperature should be further increased, and the inactivation effect is relatively general.

3.1.2 Ultraviolet Treatment Method

Ultraviolet rays at 240-260nm have a good inactivation effect. It has been found in practice that ultraviolet rays at 253.7nm can inactivate most pathogens and organisms in ballast water. However, in practical applications, since the ballast water contains a large number of suspended solids and dissolved organic matter, it will not only block the radiation of ultraviolet rays to pathogens and organisms, but also absorb ultraviolet rays (especially ultraviolet rays with a wavelength of 254 nm) to a certain extent. The effect of UV inactivation treatment will be reduced. At this time, the ballast water must be pretreated to ensure the inactivation effect. In addition, if the content of iron in the ballast water is relatively large, it is easy to accumulate in the position of the quartz lamp tube, so the effect of ultraviolet inactivation treatment will be unsatisfactory.

3.1.3 Ultrasonic Treatment

Relying on the indirect reflection generated by ultrasonic waves can realize the inactivation treatment of various organisms in ballast water, which is a long-term ballast water treatment method. For ultrasound, it can generate heat and the deflection of pressure waves to form a vacuum or semi-vacuum state, so that the organisms in the ballast water are deoxygenated and eventually die. However, ultrasonic treatment will not only generate noise, but also damage the health of ships and personnel to a certain extent, so it is not an ideal ballast water treatment method (Yin Haishan, 2017).

3.2 Chemical Treatment Technology

One chemical method is to change the composition of ballast water by adding chlorine or chlorine, ozone, hydroxyl substances and hydrogen peroxide; the other is to produce some materials with strong oxidative sterilization effect similar to the former by some catalytic means. However, the control of additives is affected by many factors, the storage and management are difficult, and the impact on pipelines, ballast tank structure and painting cannot be ignored. Catalytic methods include electrolysis, ionization, optical radiation fission, and the like. TECHCROSS (Korea) adopts electrolysis directly, and the corresponding equipment has obtained IMO certification and official certification of some countries, but the actual application effect of ships still needs further testing.

3.2.1 Chlorination

The effect of biological inactivation in water can be achieved by directly adding chlorine or hypochlorous acid to the ballast water to be treated. Practice shows that adding sodium hypochlorite to ballast water and treating with 1, 3, 5, 10 ppm of available chlorine can achieve a higher biological inactivation effect. At this time, the maximum mortality rate of aquatic organisms (marine zooplankton and phytoplankton) obtained was 76.8%; under the conditions of different available chlorine concentrations, the obtained inactivation efficiency did not differ much, and the gap between the maximum mortality rate was all within 5%.

3.2.2 Ozone Treatment

Ozone is less stable but extremely oxidizing, and can quickly complete the inactivation of viruses and bacteria in ballast water, including spores that are difficult to inactivate. Under the condition of good water quality, using 1-2 mg/L of ozone to contact the ballast water for 5-10 minutes can achieve a relatively ideal inactivation effect; under the condition of poor water quality, the concentration of ozone needs to be increased. In practice, it should be noted that when the pH value is large, the inactivation efficiency of ozone decreases; when the pH is stable between 6.5 and 8.0, the reaction effect of ozone is more stable and the inactivation effect is better.

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3.2.3 Seakleen Processing

American researchers extracted a natural insecticide ingredient from natural substances and named it Seakleen. The substance can realize the inactivation treatment of planktonic crustaceans, bivalves' larvae, Daphnia, Vibrio, fish larvae and eggs, dinoflagellates and their spores in ballast water.

3.3 Mechanical Processing Technology

3.3.1 Mechanical Method

Mechanical methods include filtration, cyclone separation, dilution and the like. The filtration method can directly remove different aquatic species by selecting the appropriate mesh, and this method has a low initial installation cost. However, the ballast water contains a large amount of flocculant, which is easy to block the filter. Therefore, ship ballast water is usually pretreated by filtration. Cyclone separation is a method of separating particles and aquatic organisms of different specific gravity from seawater by gravity separation of rotating parts. This method is simple and the cost is reasonable. However, due to its large size, it has not been developed and applied in some actual large-flow ships. Dilution is a method of injecting fresh water from the top of the ballast tank and discharging it from the bottom of the ballast tank. The dilution method only applies to new ships in connection with improvements or additions to the ship's equipment and piping.

3.3.2 Mechanical Separation Method

The mechanical separation method is generally used as a pretreatment method for deep processing, with simple operation and large processing capacity. These methods mainly include filtration, cyclone separation, dilution, flotation sedimentation, high flow rate, etc., which have the least harm to the environment and are easy to operate. Compared with other processing methods, the mechanical separation method has simpler operation and stronger processing ability. In mechanical separation, key technologies include high flow rate, filtration, dilution, cyclone separation, flotation sedimentation, etc., which have lower negative impacts on the marine ecological environment. Among them, filtration and cyclone separation are the more commonly used mechanical separation techniques. For filtration, pathogens and organisms in ballast water can be effectively removed, and the more meshes used, the better the treatment effect. Practice has shown that filtration treatment can remove 93% of micron-scale plankton, 100% of pico-scale plankton, and 62% of nano-scale plankton in ballast water. For cyclone separation, the removal of organisms in ballast water is mainly achieved by the separation effect formed by the high-speed flow of water in the pipeline. Practice shows that when the operating flow of the cyclone separator is 200m3/h, the microorganisms above 40μm in the ballast water can be effectively filtered out.

3.4 Replacement of Ship Ballast Water

3.4.1 Evacuation Method

The ballast water in all ballast tanks is emptied one by one and re-injected into ocean water. The key point of this method is to empty one by one instead of all at once. If one-time emptying and new ocean water injection are used, 95% of the original ballast water can be renewed, of which about 25% of the original ballast water still exists, causing a greater risk of adverse consequences. way to avoid this problem. When using the emptying method to treat ballast water, it is necessary to monitor and maintain the stability and trim of the ship in real time to avoid negative effects on the inherent shear force and bending of the ship. In addition, in order to ensure the safety of ship operation, the emptying method should not be used in bad weather conditions (Hou Yuehui,2018).

3.4.2 Injection and Ejection Method

The suction of ocean water at the bottom of the ballast tank and the discharge of ballast water at the top of the ballast tank are carried out simultaneously. With the support of this method, 0.5 times the cabin capacity is updated by 39.2%; 0.5 times the cabin capacity is updated by 86.5%; and 2 times the cabin capacity is updated by 95%. However, this method is subject to certain limitations in practical use, such as the design of pipelines and water tanks.

3.4.3 Brazilian Dilution Method

Contrary to the injection and ejection method, the ballast water needs to be discharged at the bottom of the ballast tank, and sea water is injected at the top at the same time. This method can better drive the sediment flow out of the cabin, avoid the problem of deck icing under cold weather conditions, and achieve better ballast water treatment effect.

3.5 Heating Electrolysis

my country's main research direction in the field of ship ballast water treatment is electrolysis, and after a long period of research and demonstration, it has been recognized by the international community. In practice, the ballast water flows into the heat exchanger to achieve heating; the ballast water after heat treatment flows into the filter to remove the large particles contained in it; after filtering, it enters the ballast water pump, which is realized with the support of the cyclone separator. Separated, and passed through the electrolysis generator under the condition of maintaining a fixed flow rate; the rectifier promotes the conversion of alternating current to direct current, provides electric energy for the electrolysis generator, and completes the adjustment of the electrolysis speed of ballast water; the seawater after electrolysis treatment returns to the ballast tank , the residual bacteria and algae can be killed with the support of chlorine. The practical results show that the direct electrolysis of raw ballast water combined with chlorine treatment can kill four kinds of algae, the total killing rate is 72%, the killing rate of bacteria is 99.99%, and ciliates can be killed at the same time; Chlorine treatment, the killing rate of Artemia in ballast water after 48 hours of contact is higher than 95%; the killing rate of living organisms reaches 95% after 24 hours of contact, under the condition of increasing the concentration of chlorine treatment, ballast after 12 hours of contact The killing rate of living organisms in water is 99.99% (He Detao, 2019).

4. Conclusion

In short, as long as the management and control of ship ballast water are based on sound laws and regulations, guaranteed by scientific supervision and management, supported by advanced scientific research, and in accordance with the clean production model, the pollution problem will be solved from the source. must be effectively contained. Under the background of the gradual implementation of the "Ballast Water Convention", the technology of ship ballast water treatment has achieved rapid development. Various principles, functions and types of ballast water treatment equipment have been widely used in ocean-going ships. At present, the ballast water treatment methods in our country can not only use one of the technologies, and the combination of the latest technology and a variety of methods is one of the future development trends of the comprehensive treatment of ship ballast water. It can play its respective advantages and make up for each other. Defects.).

Acknowledgments

This study was supported by the National Natural Science Foundation of China [Grant No. 51008191]. In addition, we are very grateful to the editors and anonymous reviewers for their insightful suggestions and comments on this paper.

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