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Original article

Consideration on the Maximum Allowable Dosage of Active Substances Produced by Ballast Water Management System Using Electrolysis *

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Abstract

The International Convention for the Control and Management of Ships' Ballast Water and Sediments was adopted by IMO (International Maritime Organization) on 13 February 2004. Fifty-seven ballast water management systems were granted basic approval of active substance by IMO, among which thirty-seven systems were granted final approval. This paper studies the maximum allowable dosage of active substances produced by ballast water management system using electrolysis which is an approved management system by IMO. The allowable dosage of active substances by electrolysis system is proposed by TRO (Total Residual Oxidant). Maximum allowable dosage of TRO is a very important factor in the ballast water management system when using the electrolysis methods, because ballast water management system is controlled with the TRO value, and the IMO approvals are given on the basis of the maximum allowable dosage of TRO for the treatment and discharge of ballast water. However, between various management systems approved TRO concentration of maximum allowable dosage showed large differences, ranging from 1 to 15 ppm, depending on the management systems. The discrepancies of maximum allowable dosage among the management systems may depend on whether a filter is used or not, the difference in the specifications of the electrolysis module, the kind of the tested organisms, the number of individual organisms, and the difference in the water quality, etc. Ship owners are responsible for satisfying the performance standard of the IMO convention in the ports of each country therefore need to carefully review whether the ballast water management system can satisfy the performance standard of the IMO convention or not.

Keywords: Ballast Water Management System, Ecosystem, Active Substance, Electrolysis, Electrochemical, IMO

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I. Introduction

Ships' Ballast Water which is used to maintain the center of gravity and to control the balance in order to acquire the stability of a ship is the essential element in the safe navigation of it. More than 90% of trade among nations in the world is being done by marine transportation and the seaborne trading volume which globally moves passed over 8 billion tons in 2010. Therefore, ballast water which moves all around the world amounts to billions of tons a year. It is being reported that about 7,000 species of organisms are being moved included in ballast water all around the world. That causes not only ecosystem disturbance but also much damage to coastal industry or other commercial activities or resources.

International Convention for The Control and Management of Ship's Ballast Water and Sediment was adopted by IMO (International Maritime Organization) in February 2004. In order to satisfy the discharge standard while discharging ballast water by this convention, it is essential to install Ballast Water Management System. The amendment of Ballast Water Management Convention was discussed and Resolution A.1088(28) was adopted in the 28th Assembly of IMO in November 2013 (IMO, 2013). According to this resolution, the definition of new constructed ship was changed from 'constructed in or after 2009' to 'constructed in or after the entry into force of the convention' and the period of management system installation was changed from 'first intermediate or renewal survey' to 'first renewal survey'. Therefore, it seems that the installation of ballast water management system will be delayed from 5 years to 7 years.

This convention shall enter into force twelve months after the date on which not less than 30 States, the combined merchant fleets of which constitute not less than 35 percent of the gross tonnage of the world's merchant shipping have deposited the requisite instrument of ratification. As of June 2015, 32.86 percent of the gross tonnages of 44 States were ratified, however, though the requirements of 30 States were met, requirements of 35 percent were not met, so the requirement of entry into force has not been arranged yet. If the requirement of entry into force of convention is arranged in the end of 2015, the convention will take force from the beginning of 2017, a year later, and the existing ships all must install ballast water management system within 5 years from it as shown in Table 1 (IMO, 2013).

Table 1: Application Schedule of the IMO Ballast Water Convention

Period for Survey Period for Performance Standard

Ship Constructed	Ballast Water Capacity	'08	'09	'10	'11	'12	'13	'14	'15	'16	'17	'18	'19	'20	'21	'22
Before 2008	Less than 1500 m³															
	1500 - 5000 m³															
	Greater than 5000 m³															
2009-2011	Less than 5000 m³															
	Greater than 5000 m³															
After 2012	All															
After 2017	All															

From the beginning of the adoption of the IMO ballast water convention, United States of America has insisted that the discharge standard should be made stringent discharge standard. US issued a rule for discharge standards for living organisms in ships' ballast water discharged into waters of the US. The rule regulates with a phase-one discharge standard consistent with the discharge standard adopted by IMO. And the rule states also its intention to establish a more stringent phase-two discharge standard in the future if the phase-two standard is technologically available.

II. Approval of Ballast Water Management System

2.1. Procedure of Approvals

Ballast water management system means mechanical, physical, chemical, and biological processes, either singularly or in combination, to remove, render harmless, or avoid the uptake or discharge of harmful aquatic organisms and pathogens within ballast water and sediments. In order to develop and commercialize the management system, when active substance is used, the approval that it is safe in terms of the ship, its equipment and the crew must be granted by IMO. Active substance means a substance or an organism, including a virus or a fungus that has a general or specific action on or against harmful aquatic organisms and pathogens. If the management system conducts only physical treatment, or, not produces active substance, such as UV, only administration type approval must be granted, not IMO Active Substance Approval.

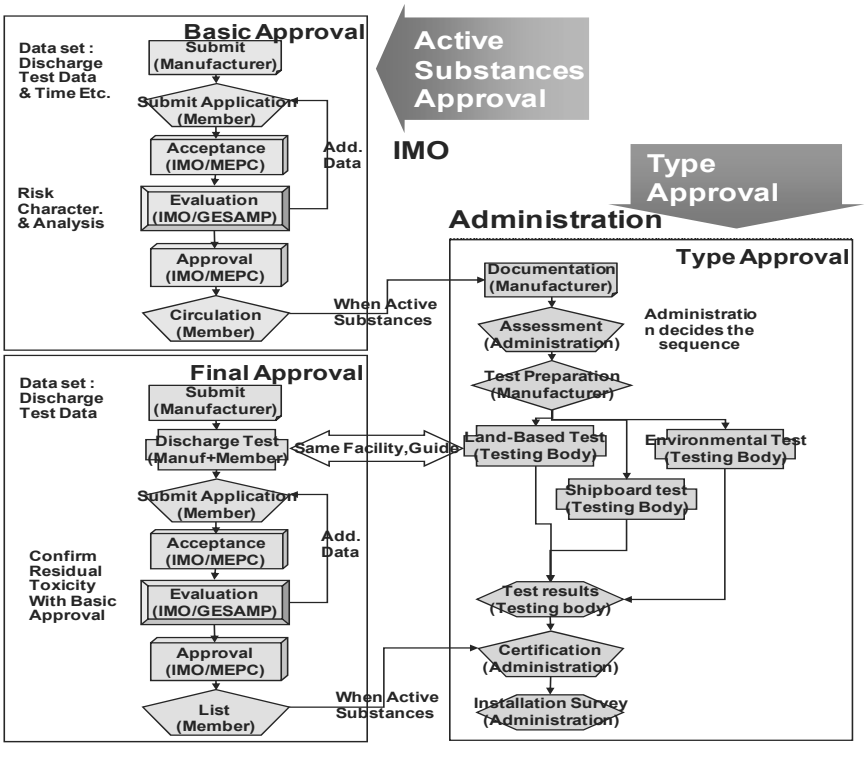

Figure 1: Procedure of IMO Active Substance Approval

Source: Kim (2008), p.216.

After the IMO approval, a type approval must be granted by the administration. In order to receive the type approval, land-based testing, shipboard testing and environmental testing must be conducted. Land-based testing is a test of the management system carried out in a laboratory, equipment factory or pilot plant including a moored test barge or test ship, to confirm that the management system meets the discharge standards set by Regulation D-2 of the convention. Shipboard testing is a full-scale test of a complete system carried out on board a ship to confirm that the management system meets the discharge standards set by Regulation D-2. In order to confirm if the management system properly operates in the environment of a ship, environmental testing must be conducted. Figure 1 shows entire procedure of the approval of management system (IMO, 2008a, IMO, 2008b, Kim, 2008).

2.2. Approved management Systems

As of August 2015, fifty-seven management systems were granted basic approval by IMO, among which thirty-seven systems were granted final approval. Figure 2 shows the number of IMO approved management systems by MEPC sessions which are summarized from the reports of the first to thirty-first meetings of the GESAMP-Ballast Water Working Group (GESAMP-BW, 2006-2015).

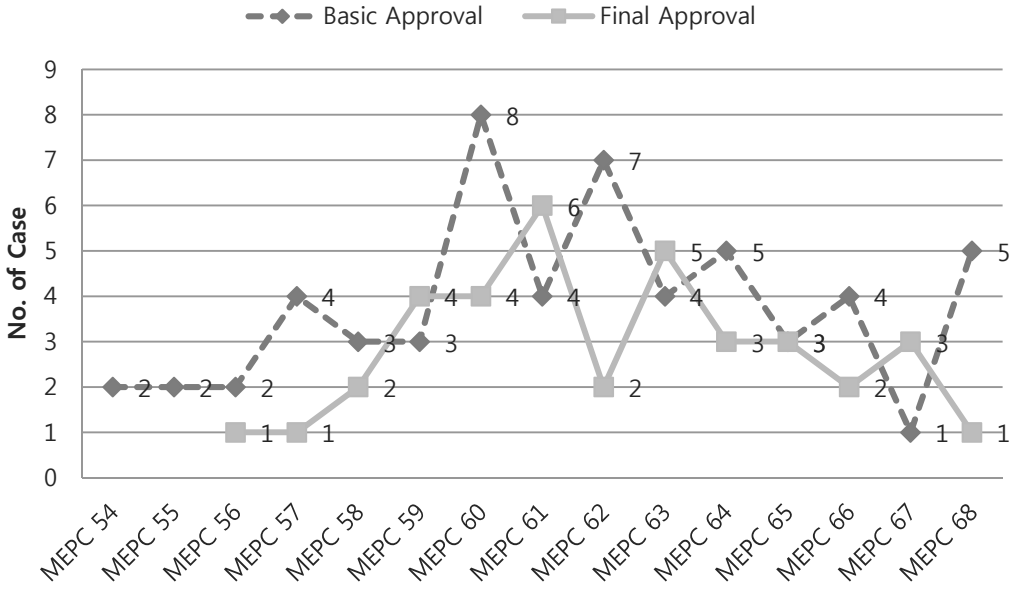

Figure 2: Number of IMO Approved Ballast Water Management System

When the management systems which were granted basic approval were examined by nations, among 57 cases, they are in the order of Korea (20 cases), followed by Japan (11) and Germany (7). When the management systems which were granted final approval were examined by nations, among 37 cases, they are in the order of Korea (12 cases), Japan (8) and Germany (7).

Figure 3 shows the distribution by treatment methods of the management systems which were granted IMO basic approval. The electrochlorination method that a high dosage of hypochlorous

acid is manufactured and diluted are the most (15 cases), followed by electrochemical method which treats ballast water generating various radicals and a low dosage of hypochlorous acid (13). Besides that, there are the methods that treat ballast water, generating the ozone(4), ones that use various chemicals(8), and others(8). It was announced by IMO that UV method isn't the subject of active substance approval as there is no active substances at present, however 7 cases have been already approved (GESAMP-BW, 2006-2015).

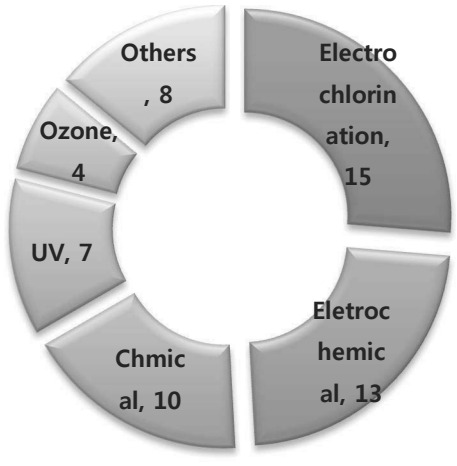

Figure 3: Comparison of Number of IMO Basic Approval between Various Technologies

As of June 2015, fifty-three management systems in total were granted type approval. Examined by nations, they were in the order of China (10 cases), followed by Japan (9), Korea and Norway (8), and Germany (7). Examined by treatment methods, they was in the order of UV method (27), followed by electrochemical method (5), electrochlorination method (5), and chemicals method 6) (GESAMP-BW, 2006-2015).

III. Allowable Dosage of Active Substances

There are electrochlorination method and eletrochemical method in the electrolysis method management system.

Electrochlorination method is one that sea water is electrolyzed, a high dose of hypochlorous acid is made, it is diluted with ballast water, and aquatic organisms within the ballast water are oxidized and rendered harmless. Without the need of the transportation and storage of chemicals, hypochlorous acid is made through electrolysis onboard and is used.

Eletrochemical method is one that the whole ballast water is electrolyzed, the aquatic organisms within the ballast water are rendered harmless by radicals and a potential difference, and some of surviving organisms are oxidized and rendered harmless by the residual chlorine.

TRO (Total Residual Oxidant) is a generic term for these kinds of oxidants. Most of management systems control the treatment and discharge concentrations of them with TRO value, measure TRO value in real time, and based on it, control electric power. Therefore, approval

condition at the reviewing of the GESAMP-BWWG of IMO is given as TRO value while treating and that while discharging. Figure 4 shows maximum allowable treatment dosage and discharge concentrations of TRO for the electrochlorination method which were granted basic approval from IMO. In 15 management systems by electrochlorination method, TRO concentration while treating showed a distribution of between maximum 15 ppm and minimum 2 ppm, however, TRO concentration while discharging mostly showed 0.2ppm.

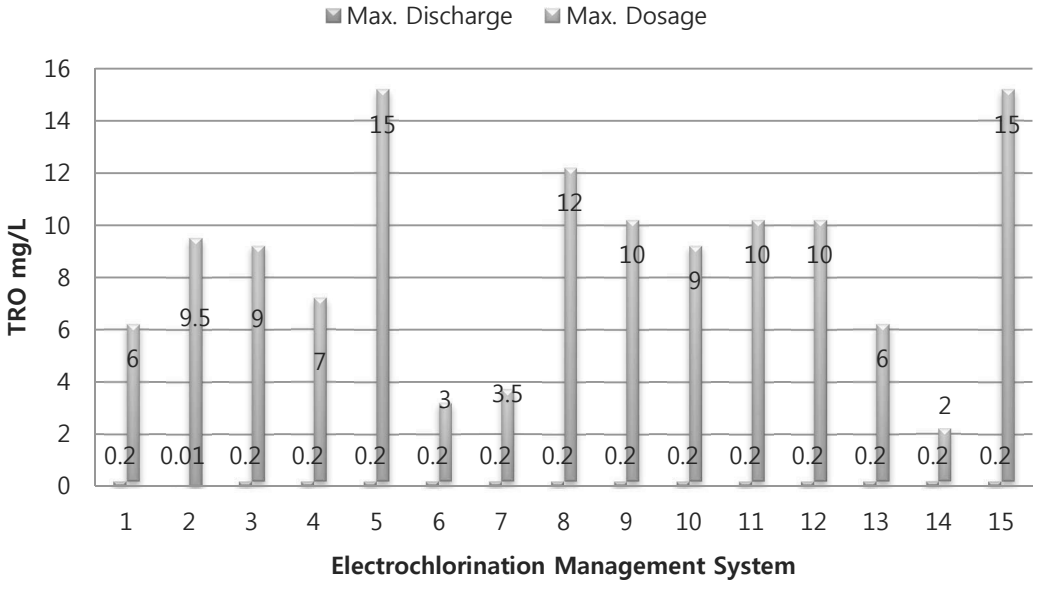

Figure 4: Maximum Allowable Treatment Dosage and Discharge Concentrations of TRO for the Electrochlorination Method for the IMO Basic Approval

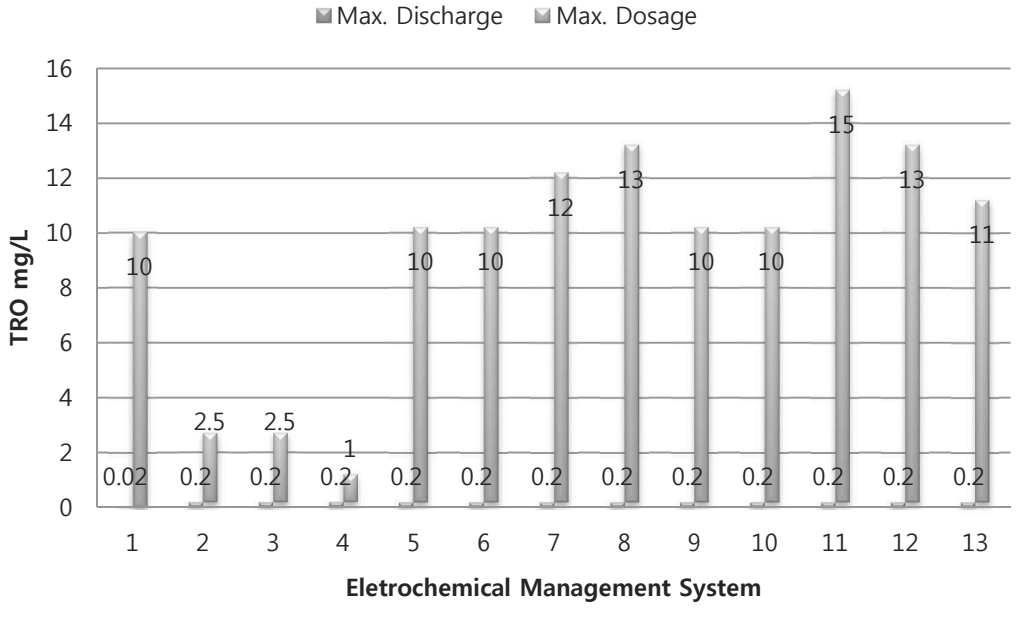

Figure 5: Maximum Allowable Treatment Dosage and Discharge Concentrations of TRO for the Electrochemical Method for the IMO Basic Approval

Figure 5 shows maximum allowable treatment dosage and discharge concentrations of TRO for the electrochemical method which was granted basic approval from IMO. In 13 management systems by electrochemical method, TRO concentration while treating showed a distribution of between maximum 15 ppm and minimum 1 ppm, however, TRO concentration while discharging mostly showed 0.2ppm.

IV. Consideration of Maximum Allowable Dosage

Maximum allowable dosage of TRO is very important term at the ballast water management system using electrolysis methods, because the management system is controlled with the TRO value, and IMO approvals is gave as maximum allowable dosage of TRO basis while treating and that while discharging.

TRO concentration while discharging is not so significant because it is lowered below the approved condition with the use of neutralizing agent such as sodium bisulfite, etc. But TRO concentration while treating is so significant because when treatment concentration is low, though there are advantages, such as the low creation and discharge of toxic chemicals and the little requirement of electricity, however, there are also disadvantages that that organisms are rendered harmless may not be complete.

Figures 4 and 5 showed large deviation of maximum allowable dosage of TRO by management systems for the electrochlorination and eletrochemical method which were granted IMO basic approval.

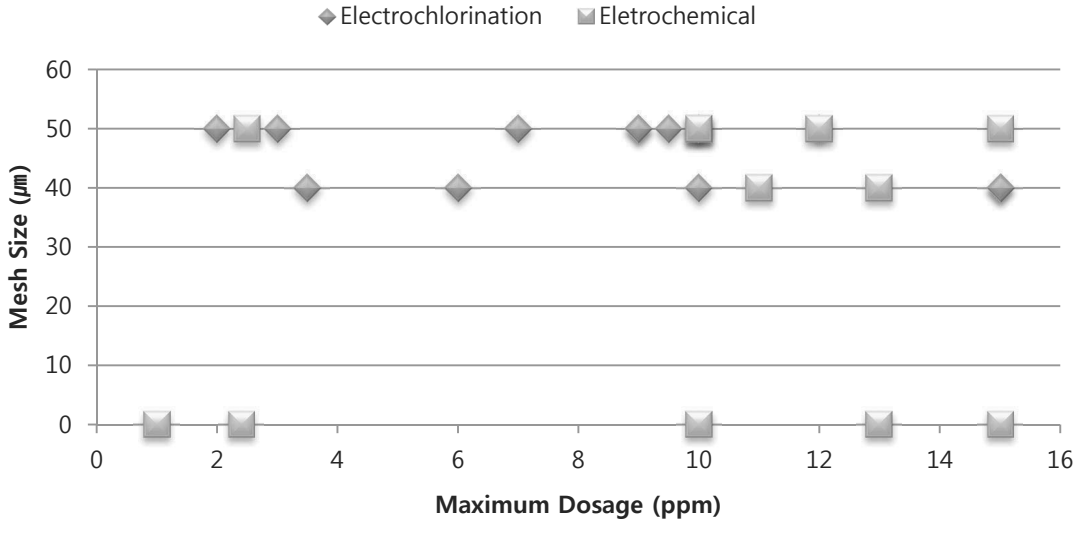

Figure 6: Relation between Mesh Size of Filter and Maximum Allowable Dosage of Preparation of TRO for the In-Direct and Direct Electrolysis Method for IMO Active Substance Approval

Figure 6 shows relation between mesh size of filter and maximum allowable dosage by these management systems for the electrochlorination and eletrochemical method. At this time, there are 5 cases where mesh size is 0, which means that filter is not used. The filter of 40~50 ㎛ mesh size is used by most of management systems, so it can be hardly said that it is due to the difference in filter.

It seems that the discrepancies in the treatment concentration are due to the differences in the kind of the tested organisms, the number of individual organisms, the difference in the water quality, such as water temperature or turbidity, whether a filter is used or not, and also the characteristics of the products, such as the specifications of the electrolysis module.

Although IMO is trying to enhance the standard condition on the organism test, it is considered that it will be very difficult to consider the organisms at the test conducted in everywhere in the world, and the water qualities of it. Therefore, it seems that the exact assessment of treatment concentration on it will be done through the sampling examination in the port of each administration which confirms whether discharge standard is satisfied after the effectuation of convention. Especially, in order to manufacture the management system which can satisfy the discharge standard of the phase-two stage of US, highly concentrated TRO is being used recently.

V. Conclusions

After having considered the active substance concentration of the management system which granted active substance approval from IMO, the conclusions may be drawn as follows. When the management systems which use electrolysis method were divided into the electrochlorination and electrochemical method, the differences in the TRO concentration for ballast water treatment was very big depending on the management systems. It is considered that the causes of this deviation may be whether a filter is used or not, the difference in the specifications of the electrolysis module, the kind of the tested organisms, the number of individual organisms, and the difference in the water quality, etc.

It is considered that there is no significance as most of the TRO concentration while discharging gets lowered to 0.2ppm, because this TRO concentration does not only affect the ecosystem disturbance but also the coastal industry or other commercial activities or resources. With the effectuation of the ballast water convention, after the samplings which assess whether the discharge standard is satisfied or not in the port of each administration, it seems the issue of whether the concentration of the active substance of each management system can satisfy the convention or not may emerge again. As ship owners are responsible for satisfying discharge standard in the port of each administration, it is considered whether the management system to be installed can satisfy IMO convention or not must be carefully reviewed by the ship owners.

Ship owners are responsible for satisfying the performance standard of the IMO convention in the ports of each country therefore need to carefully review whether the ballast water management system can satisfy the performance standard of the IMO convention or not.

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