NK Activities toward the Entry into Force of the International Convention for the Control and Management of Ships' Ballast Water (2nd Report)

1. Introduction

According to the IMO, about 3 to 5 billion tons of ballast water are transported internationally by ships every year, and discharge of the ballast water is considered to have serious effects on the protection of marine ecosystems. On this basis, the 'International Convention for The Control and Management of Ships' Ballast Water and Sediments, 2004' (hereafter referred to as 'the Convention') was adopted in February 2004 to prevent movements of harmful aquatic organisms in ballast water discharged from ships from being transported across borders.

When we consider the recent growing interest in the protection of the global environment and gradual increase in the number of countries ratifying this Convention, it is expected that it will come into effect in the near future.

Although the Convention will be applied to ships in service, it appears that, since installation space is limited, there are many problems in relation to compliance of ships in service with the Convention.

On this basis, we determined the problems in installing the system to ensure compliance with the Convention (hereafter referred to as 'the water treatment system') and organized the issues to be discussed to explain how they should be handled in a technical seminar held in the Fall of last year. We have subsequently implemented a trial design for ships in operation, and this article describes the procedures for installing the system, including design results as well as approval of drawings.

2. International convention for the control and management of ships' ballast water and sediments

2.1 Conditions for implementation of the convention

For the Convention to come into effect, Article 18 states that the Convention shall come into effect twelve months after the date on which not less than thirty States, the combined merchant fleets of which constitute not less than thirty-five percent of the gross tonnage of the world's merchant shipping, have ratified the Convention. As of February 2010, twenty three countries, amounting to 22.65 % of the total world tonnage. The number of approved ballast water treatment systems has also increased, and this is expected to further accelerate ratification and drive implementation of the Convention.

2.2 Application of the convention

Application of the Convention is described in Article 3. Application of the ballast water management rules is specified as 'exclusion of application' and 'exemption' in Annex A-3.

The Convention is applicable to the following ships.

(1) Ships of States Party to the Convention

Ships without registration in any state party to the Convention but managed under the authority of a state party to the Convention.

And the Convention will not be applicable in the following cases:

(a) Ships not designed to carry ballast water, or having no such construction.

(b) Ships operating only in waters under the jurisdiction of a state party to the Convention, and for which discharge of ballast water will not affect the environment and human health within the state.

(c) Ships from one state party to the Convention which operate only in waters under the jurisdiction of another state party to the Convention which has approved the ships for

exclusion of application of the Convention for operation in its zone.

(d) Ships operating only in waters under the jurisdiction of a state party and on the high seas and for which discharge of ballast water is considered by the state party to the Convention to have no effect on the environment or human health, except for ships whose exemption from application of the Convention is not approved according to above (c).

(e) All warships, naval vessels and ships owned by the national government or operated by the government serving in governmental nonprofit operations.

(f) Permanent ballast water in sealed tanks that is not discharged.

On the other hand, the ballast water management standard will not be applicable in the following cases:

(1) Intake or discharge of ballast water to ensure safety of the ship in case of emergency or to save lives at sea.

(2) Discharge of ballast water caused by accidents or flooding due to damage to the ship.

(3) Intake of ballast water to avoid or minimize pollution caused by the ship.

(4) Intake and discharge of ballast water in high seas.

(5) With the condition that it would not be mixed with uncontrolled ballast water, intake of ballast water and discharge of the ballast water taken in at the same location.

In addition, the ballast water discharge standard will not be applied to ships which discharge ballast water into reception facilities conforming to the standard developed by the IMO.

2.3 Date of application of regulation D-2

The date of application of the ballast water management standard (Regulation D-2), the core of the Convention, is specified in Regulation B-3. It is outlined in Table 1. If the requirements for the Convention to come into effect are satisfied in August 2011, it will come into effect in August 2012. Ships in service and built in 2009 or later, and with ballast water capacities smaller than 5000 m3, will then be required to conform to the Convention on the day it comes into effect.

Furthermore, the date of construction of the ship is defined as the date on which the keel was laid, the point in time at which the ship was built to be recognized as a specific ship, or at the point in time when either 50 tonnes or 1 % of the estimated total building materials have been assembled for the specific ship, in the same manner as noted in Chapter 2 of SOLAS II-1.

Table 1 Date of application of ballast water performance standard

	Ballast water capacity of ship	Date on which only Regulation D-2 is applicable										
		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Ships constructed before 2008	1500 ～ 5000								D-2			
	～ 1500 or 5000～										D-2	
Ships constructed after 2009	～5000		D-2									
Ships constructed between 2009 and 2011	5000～										D-2	
Ships constructed after 2012						D-2						

3. Approval and certification procedures

Ballast water treatment systems are required to conform to guidelines G9 and G8, developed by the IMO. Approval of a water treatment system is obtained by application to the IMO through the main authority based on G9 standards. Application is then followed by the IMO's examination of active substances used in the system. It is then approved by the government to which the ship is registered according to ballast water treatment system approval guideline G8. It is accepted that the classification society can give G8 approval under the authority of its government if the main authority approves. Active substances refer to chemicals used in systems to eliminate the aquatic organisms or microbes in the ballast water.

The approval procedures based on G9 comprise the two stages of basic approval and final approval, as shown in Figs. 1 and 2.

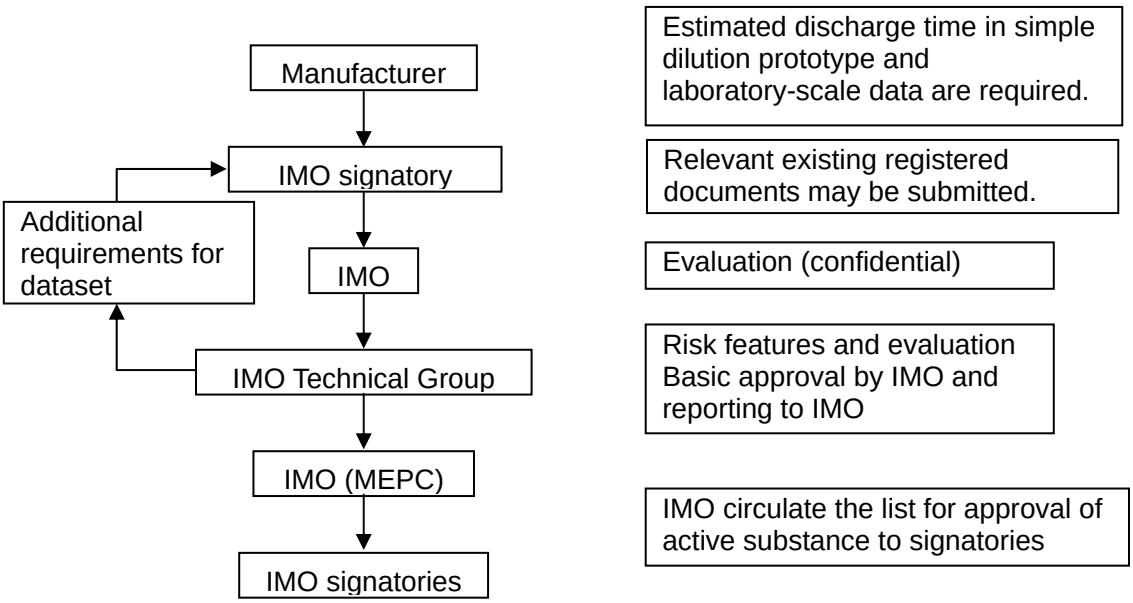

Figure 1 Basic approval procedures

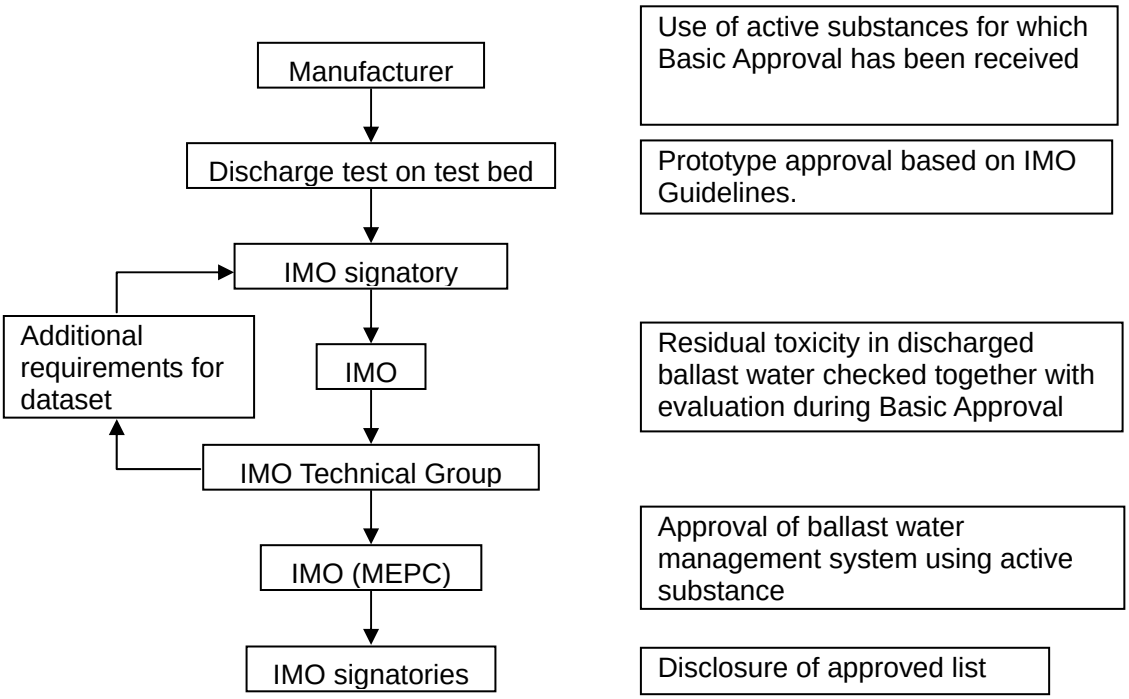

Figure 2 Final approval procedures

Examination is implemented to evaluate and verify the effects of the active substances on marine environment, ship body and crew. Verification is conducted by GESAMP (Group of Experts on the Scientific Aspects of Marine Environmental Protection), the technical group of IMO, and GESAMP recommends approval to IMO MEPC when its verification proves satisfactory. MEPC makes a review and gives approval.

There are cases in which conditions are added in approval of active substances by MEPC, and the conditions need to be examined when actually selecting the system.

In accordance with G8, the system can finally be installed in a ship when the prototype is approved after shore and shipboard testing by the government to which the ship is registered. G8 requires installation inspection for each ship when a system is installed in ships.

3.1 G8 shore testing

An outline of shore testing is shown in Fig. 3. Test water of 200 m^3 is treated and analyzed 5 days later to check if the D-2 standard values are satisfied. Two types of water are selected from seawater, freshwater and brackish water, and test is repeated 5 times for each type of water to check that the standard values are satisfied.

Test water of 200 m^3 is drained into the treated water tank via the water treatment system. Meanwhile, untreated water of the same volume is also collected in the untreated water tank. Samples are taken five days later to check that the standard values are satisfied. The test water collected in the untreated water tank is used to verify that the treatment system is providing meaningful treatment by comparison. It is considered that the effect of the treatment system cannot be confirmed if the organisms within the test water die out in 5 days.

3.2 G8 Shipboard testing

Shipboard testing is conducted for six months or more with water filling and discharge operation of normal ballast water on one or more ships at the rated capacity of the ballast water treatment system. The results of a total of three chemical analyses are reported to the main authority.

As a large number of procedures and tests are required for approval of the treatment system, it is not practical to obtain approval for all governments to which ships are registered by conducting all approval tests required for the system. The guideline therefore specifies that the type approval certificate can be issued by a main authority based on tests conducted under the supervision of another main authority.

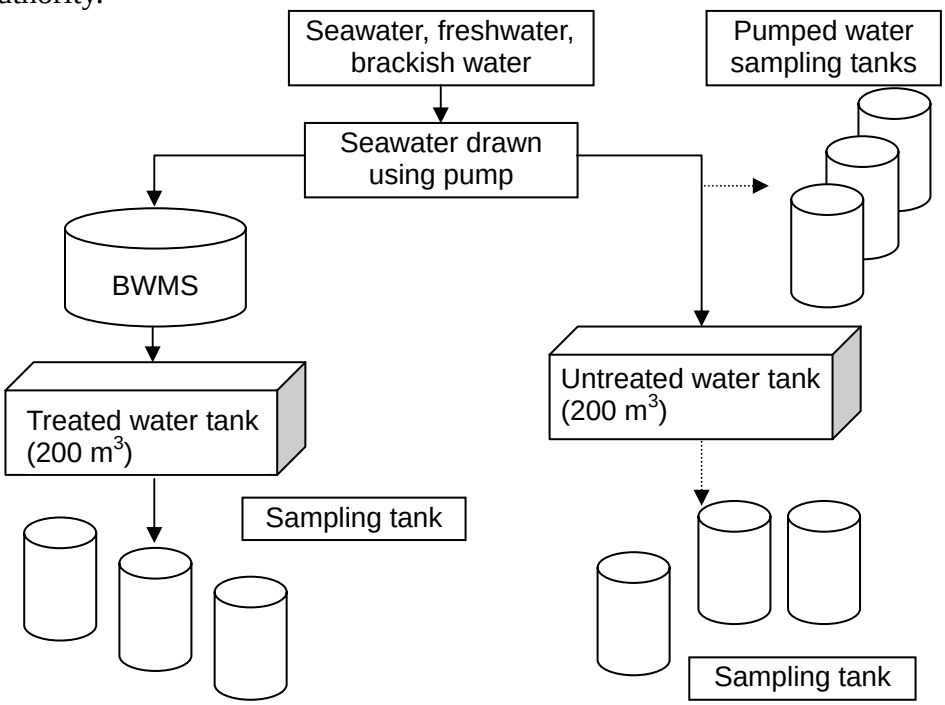

Figure 3 Shore testing

4. Outline of approved products

As of January 1, 2010, the following 8 systems have been approved under G9 (excluding Venturi Oxygen Stripping) and G8.

1. Alfa-Laval - PureBallast
2. Ocean Saver AS - OCEAN SAVER
3. Hamann - SEDNA
4. NEI Treatment - Venturi Oxygen Stripping
5. Techcross Inc. - Electro-Cleen System
6. Hyde Marine Inc. - Hyde GURDIAN
7. Optimarine AS - OptiMar Ballast System
8. Hitachi Plant Technologies, Ltd. - Clear Ballast

The basic concept for these ballast water treatment systems is shown in Fig. 4.

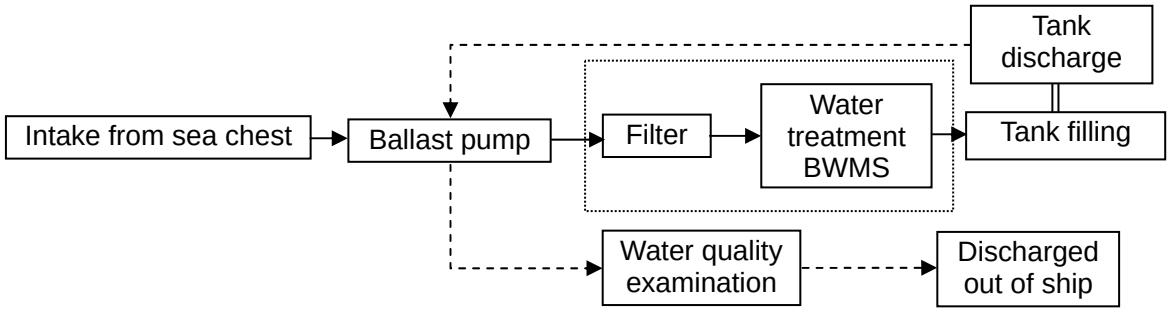

Figure 4 General flow in ballast water treatment

Seawater is taken in from the sea chest using a ballast pump and sent to the filter to remove organisms and foreign substances of sizes normally 50μm or larger. Bacteria are then killed using physical systems or active substances. The treated water is led to the ballast tank. Ballast discharge from the ship is implemented by taking the ballast water from the ballast tank using ballast pump and adjusting the water quality (neutralization or treatment of regenerated substances) if necessary. With water treatment using activated substances, chemicals supplied from outside the ship or generated by electrolysis of water act to kill off microbes and bacteria. Physical systems include those using ultraviolet light. At present, mainstream water treatment systems combine active substances, or ultraviolet and filters.

Overview of currently approved and some typical systems are shown in the Appendix for reference.

5. Ballast water treatment systems

The following examination process may be necessary when installing a ballast water treatment system.

- Check on specifications and outline of equipment on the ship.
- Examination of requirements such as desired performance of the ballast water treatment system.
- Selection of the ballast water treatment system.

In accordance with this process, matters to be examined are considered in equipment design.

5.1 Confirmation of equipment specifications for the ship

Devices necessary for ballast water filling and discharge, including ballast water piping and ballast pumps are installed inside the engine room. This is therefore the most rational location for the ballast water treatment system. Based on the general layout and engine room layout, the possible area and height to be assigned to the water treatment system is checked to examine the location of installation.

It is expected that the space in the engine room has been minimized in recent ships to maximize cargo areas, and it may therefore be difficult to find a location for installation. In such cases, it is possible to consider exposed sections such as the upper deck or the wheelhouse as possible installation spaces.

The pump room is a possible location for installation in tankers, however, pump rooms are considered to be hazardous areas due to electrical equipment, and it is therefore required to be explosion-proof.

5.1.1 Ballast pump and piping

The pump discharge capacity and pressure for filling and discharging ballast water is checked. In addition, it is possible to estimate the effect of Head Loss in ballast water treatment systems if the QH curve for the corresponding ballast pump is available.

In emergencies it is preferable to use one pump as a standby for fire-fighting if there are two pumps (fire-fighting and ballast pumps) available. If both pumps are used in filling and discharge of ballast water and the engine room is regularly unmanned, measures such as pump startup and switching of the valve on discharge side by remote control from the bridge, or location of fire control to enable quick water supply to the main pipe for fire fighting are necessary.

In addition to pumps, ballast operation procedures are also checked on the ballast piping system diagram. Operation procedure documents are prepared by also checking the existence of eductor and stripping line.

When selecting a system using activated substances, checks of ballast piping materials and ballast tank interior painting materials are required.

5.1.2 Power generator capacity

Power usage status during cargo handling and the maximum power usage for the plan are checked using the power investigation table for the ship.

Power consumption when cargo handling facilities and ballast pumps are used, as well as power consumption of operating systems, are also checked.

5.1.3 Check on current conditions

It is desirable to check on the current conditions on the ship to determine if there have been any modifications subsequent to completion, even if completed drawings are available for the ship.

5.2 Design conditions for ballast water treatment systems

5.2.1 Time required for ballast water discharge

It is important to establish the time required for filling and discharging ballast water when selecting the ballast water treatment system. Since the time required for cargo handling is influenced greatly by the ballast water filling and discharge time, the ship operation and cargo handling status need to be checked to determine the ballast water filling and discharge time.

5.2.2 Other design conditions

(1) Upper deck section

Caution is required when a ballast water treatment system is installed on the upper deck and enclosed in a casing since the projection area for the ship increases with the equipment numbers. Furthermore, the effect of increasing total tonnage through increased enclosed area is checked and incorporated in system and equipment planning.

It may also be necessary to check the intact stability.

(2) Cruising distance

In systems that consume fuel to treat the ballast water, a storage tank to match the required quantity is necessary. If using parts of the existing fuel tank, it should be noted that fuel for ship operation may decrease, thus reducing cruising distance.

(3) Discharge by eductor

In planning the discharge of ballast water using an eductor, addition of devices for the ballast water treatment system, review of pipe diameter for eductor-related systems, and review of the driving pump specifications would be necessary by considering the treatment method of the ballast water treatment system.

(4) Gravity discharge

Ballast water may be discharged directly out of the ship by gravity without the ballast pump in the engine room if the ballast tank is located above the water line. It may be necessary to check ballast filling and discharge procedures for ships re-treating (including neutralization) and draining water in ballast tanks.

(5) Operation routes

Ships calling at ports in the US are required to conform to the ballast water management rules of the US in addition to IMO standards. It is necessary to determine whether there are ports on the route capable of supplying the active substances when systems using active substances are used.

The ballast water treatment system needs to be capable of supporting salt concentrations covering seawater to freshwater on routes going upstream in rivers

5.3 Selection of ballast water treatment system

In selecting the ballast water treatment system, the issues discussed previously are considered in order to select the system most appropriate for the ship.

5.3.1 Processing method for ballast treatment system

Since the mainstream treatment methods in these systems combine filters with active substances, electrolysis or UV, compatibility between generated or added chemicals and paint on ballast tanks previously checked needs to be examined.

It is possible to make a preliminary selection of the systems at this point to narrow down the systems according to the following procedures.

5.3.2 Process timing in ballast water

With systems in which ballast water is treated at intake and then injected into the ballast tank, requiring no neutralization or re-treatment at discharge, it is possible to discharge water directly from the ballast tank by gravity. Use of a discharge by eductor is also possible. In oil tankers, it is possible to inject water into a ballast tank adjacent to the cargo tank using the ballast pump in the engine room using special measures.

5.3.3 Head loss

Reduction in pump discharge flow rate is estimated based on the head loss in the ballast water treatment system and the QH curve for the pump checked previously. Installation of a booster pump should be considered if the flow rate reduction is large.

Ballast pump replacement is generally considered difficult since there is a high concentration of devices and piping is around the pump.

It should also be noted that there are systems with different head loss values for ballast water filling and discharge.

5.3.4 Capacity of power generators

The necessary power is calculated by adding the power consumption of the ballast pump, the ballast water treatment system, and other additional facilities such as booster pumps, to the power usage during cargo handling.

It is desirable to plan the load factor for the power generator as 90 % or less considering load

fluctuations in pumps and cargo handling facilities, as well as power fluctuations caused by automatic startup/shutdown of devices.

5.3.5 Activated substances

If active substances are used in the water treatment system, it is necessary to verify compatibility between chemicals and ballast piping materials or chemical filling pipe materials, as well as paint in the ballast tank. Effects on the anode should be checked if anode are installed to prevent corrosion in the ballast tank.

5.3.6 Consumables in ballast water treatment system

If chemicals are supplied from outside the ship, a chemical storage tank needs to be installed within the ship. Temperature management is required for the storage tank, and ventilation and fire facilities in the location where the tank is installed need to be examined depending on the properties of the chemical to be stored. If a chemical specified as a hazardous material is used as the activated substance in the ballast water treatment system, the ability of the crew to handle such substances must be verified.

6. Drawing approval, inspection and certificates

The following section describes the inspection items and test methods for drawing approval and installation of the ballast water treatment system in the ship.

To obtain the type approval of the water treatment system is necessary, further inspection considered is unnecessary except for system quality checks at shipment. Drawings are therefore examined before installation of the system, and system installation conditions and operating conditions are checked after installation for the classification inspection.

The drawings required for submission are listed as follows:

- Type approval certificate (G8) (issued by the government to which the ship is registered)
- Ballast water management plan
- Ballast water treatment system installation specification document
- General arrangement drawing (regarding system layout)
- Piping layout (hull and machinery spaces)
- Electrical circuit drawings (including investigation tables of electrical power, short-circuit current calculation sheet and explosion-proof specifications)
- Main power cable drawings
- Power calculation document
- Initial calibration procedure document

When investigating drawings, whether or not the ballast water treatment system will inhibit safe operation of the ship according to the current steel ship rules and treaties is determined by considering the following points:

- Safe location for installation of chemical tank
- Safe supply and handling of chemicals within the ship
- Segregation of dangerous ballast and safe ballast
- Use of explosion-proof devices in hazardous locations
- Installation of sampling devices for ballast water discharge
- Whether the power generation capacity necessary for safe operation is ensured

In inspection of the ballast water treatment system installation, it is assumed that the following items are verified.

- Ballast water treatment system is installed according to the installation specification document.
- Ballast water treatment system matches the prototype approval document.
- Ballast water intake and drain openings are installed according to the approved drawing.
- Piping sections that penetrate walls satisfy the requirements by steel ship rules.

- Water filling test procedure (including operation check on control system, monitor and so forth)

After confirming the above items, shipboard testing and inspection is implemented according to the submitted shipboard test procedure.

When inspection is complete and it is confirmed that the ballast water management system conforms to the Convention, the international ballast water management certificate is issued from the government to which the ship is registered (when the authority to issue the inspection and certificate regarding the Convention is obtained from the government, NK will issue them). At present, the Convention has yet to come into effect, and we therefore issue the statement of fact after approving drawings and installation inspection previously described, if applied for by a ship installing the ballast water treatment system. It is considered that ships with the appraisal certificate will be able to switch to the Convention certificate smoothly without submission of the related drawings and installation inspection when the Convention comes into effect.

7. Conclusions

When the Convention comes into effect, all newly built ships, and many ships already in service, will be subject to the Convention in 2015 and later. The great challenge for ships in operation is installation of ballast water treatment systems in the limited space. It is expected that guidelines for minimizing the effects on ship operation and cargo handling procedures, and installation of an efficient ballast water treatment system with high cost-effectiveness will be required. NK has prepared the ‘Provisional Guidelines for Installation of Ballast Water Treatment Systems’ to assist in equipment design primarily for ships in operation. In future, we plan to provide technical support for installation of ballast water treatment systems in operating ships.

Appendix

A. Overview of approved products

Overview of typical systems are given below.

A.1 PureBallast

Chemicals brought from outside the ship for sterilization of aquatic organisms are not used in the water treatment process. In the first stage filter, large aquatic organisms are removed together with dirt. Subsequently, radicals are generated when light falls on titanium dioxide, and these radicals neutralize aquatic organisms and fungi in ballast water. An atom or a molecule with an unpaired electron is a radical. Titanium dioxide is used as the raw material in white pigment, food additive, toothpowder and so on. The titanium dioxide photo catalyst emits light at specific wavelength, and generates activated oxygen and hydroxyl radicals (OH radicals). It can safely and easily decompose various organic substances including aldehydes, dioxins, environmental hormones, odors, etc., which cause the Sick House Syndrome. Photocatalytic functions appear also because of sunlight or light from fluorescent lamps. OH radical has much greater oxidizing ability than chlorine, hypochlorous acid, hydrogen peroxide, and ozone, which are widely used for disinfection and sterilization. Ballast water needs to be passed through the ballast water treatment system again before it is discharged.

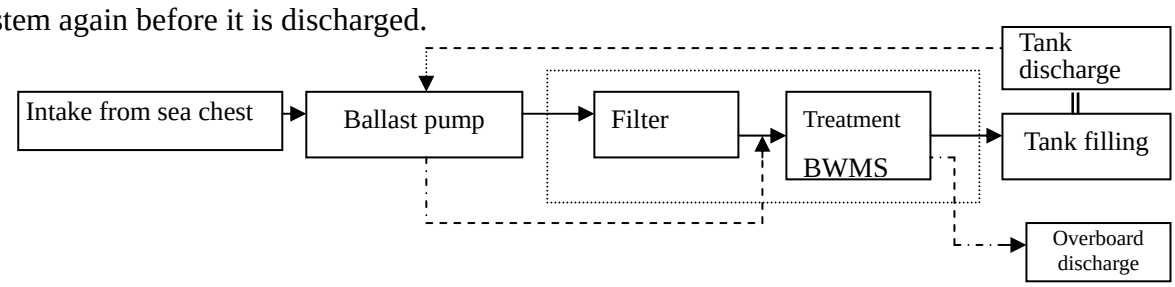

Fig. A.1 “PureBallast” System

A.2 OCEAN SAVER

No chemical substances are brought into the ship from outside the ship. The intake ballast water is passed through filters. Large aquatic organisms and dirt of 50 microns and above are removed by the filters. The ballast water is sterilized by the cavitation system. Nitrogen gas is generated on board the ship. Hydroxyl ions produced by electrolysis are added, and aquatic organisms and fungi are neutralized.

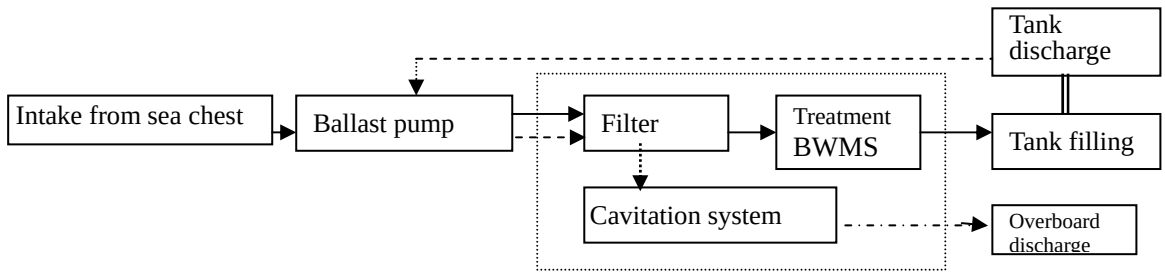

Fig. A.2 “OCEAN SAVER” System

A.3 Venturi Oxygen Stripping

No chemical substances are brought into the ship from outside the ship. Inert gas is blown into ballast water using a Venturi pipe during ballasting, the oxygen concentration in water is reduced, and the ballast water is sterilized. Even during voyage, the ballast tanks are inerted and growth of aquatic organisms is prevented. For this reason, the oxygen concentration of ballast water is low, and living organisms cannot survive. Thus, ballast water is discharged while blowing atmospheric air with the help of the Venturi pipe.

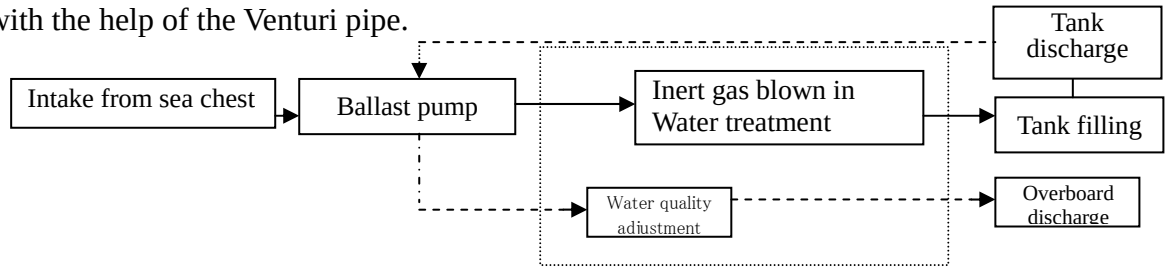

Fig. A.3 ”Venturi Oxygen Stripping” System

A.4 Electro-Cleen System

No chemical substances are brought into the ship from outside the ship. The cell nucleus is destroyed by hypochlorite (sodium hypochlorite) and free radicals in the electrolytic device. The cell membrane is destroyed by oxidative reduction potential (ORP) for realizing disinfection. On the other hand, hypochlorite is made to remain in the ballast water to prevent re-generation of micro-organisms in the ballast tank. For this reason, sodium thiosulfate needs to be added for neutralizing the hypochlorite that remains after ballast is discharged.

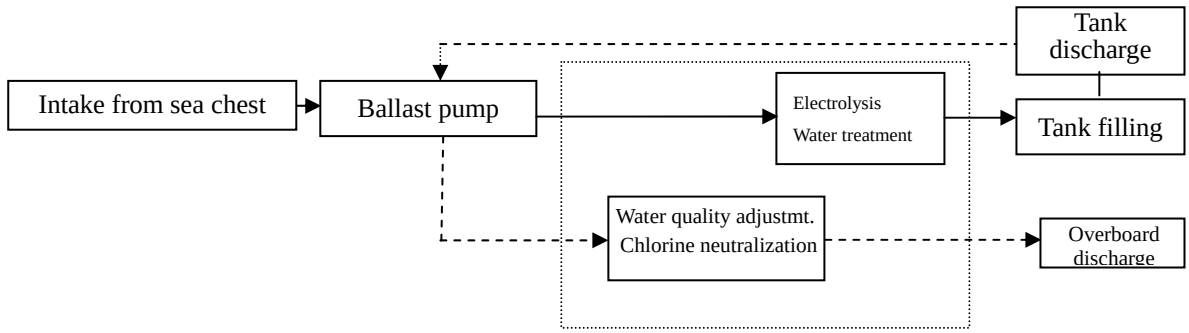

Fig. A.4 “Electro-Cleen” System

A.5 ClearBallast

Fig. A.5 shows an overview of the treatment method. This is a treatment system in which magnetic powder is introduced in ballast water after intake. By agitation and magnetic separation, aquatic organisms, micro-organisms, and microbes are neutralized. No chemicals for sterilization are used. The aqueous ingredients in ballast water are also unchanged, and re-treatment of discharged water, neutralization, etc., are not necessary.

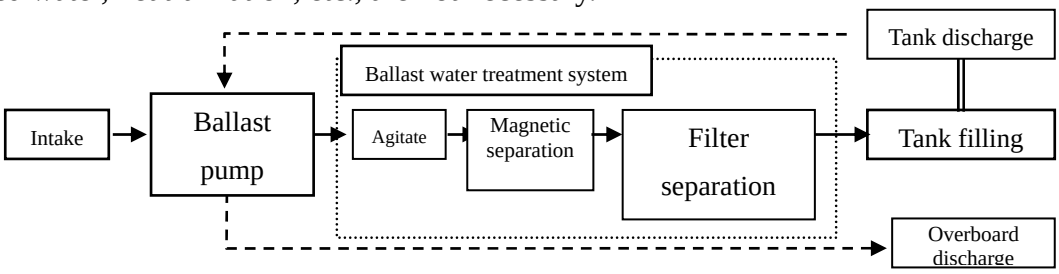

Fig. A.5 “ClearBallast” System

A.6 Hyde GUARDIAN

Chemicals brought from outside the ship for sterilization of aquatic organisms are not used in the ballast water treatment process. Fig. A.6 shows an overview of the treatment method. In the first stage filter, large aquatic organisms are removed together with dirt. Subsequently, micro-organisms, microbes, etc., are killed by ultraviolet rays. Again at discharge, the ballast water is passed through the ultraviolet disinfection unit, so that the micro-organisms, microbes, etc., reproduced in the tank are killed.

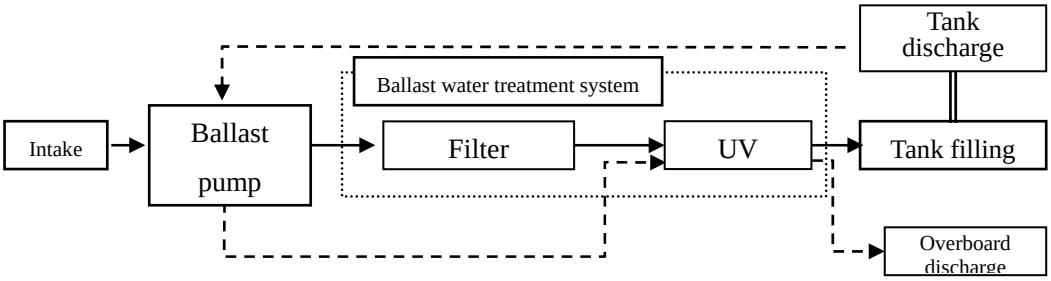

Fig. A.6 “Hyde GUARDIAN” System

Table A BWTS currently pending approval（includes already approved systems）

Name of System	① Mechanical action	② Chemical, gas	③ Electrolysis, UV system	④ Neutralization/ re-treatment at discharge	⑤ Other systems
Clear Ballast	Rapid/slow agitation, magnetic separation, filter separation systems	Inorganic coagulant magnetic powder, high polymer coagulant	---	---	Recovered floc treatment system
JFE-BWMS	Filter, cavitation	Sodium hypochlorite (UN 2693)	---	Sodium sulfite (UN 1791)	
NK-O3 Blue Ballast System	---	Oxygen generator + ozone generator	---	Sodium thiosulfate	Ozone injection system
VOS	---	Stripping gas generator	---	Aeration	Venturi tube (injector)
Electro-Cleen System	---	---	Seawater electrolysis system	Sodium thiosulfate	
PureBallast	Filter	---	Photocatalytic system (AO)	Re-treatment	Cleaning system
Hyde Marine System	Filter	---	UV	Re-treatment	
Clean Ballast	Filter	---	Electrolysis system	Re-treatment	
SEDNA System	Cyclone＋Filter	Peraclean Ocean (Class 5.2)	---	---	
Ecochlor BWT System	Filter	Dilute sulfuric acid, Purate (UN 2428)	---		
Ocean Saver	Filter＋Cavitation	Air compressor + N_2 generator	Electrolysis system	Sodium thiosulfate, aeration	Ejector
SP-Hybrid BWMS Combined with Ozone Treatment	Pre-filter, special pipe	Oxygen generator + ozone generator	Degassing layer	Drainage treatment layer	Ozone injection system
OptiMar Ballast System	Filter	---	UV	---	
Greenship’s Ballast Water Management System	Cyclone	---	Electrolysis system		

B. FAQ related to piping

	Q.	A.
1.	Is it acceptable to connect safe ballast pipe and dangerous ballast pipe?	Not acceptable at this stage, but studies are underway to check compliance with IACS URF44.
2.	If 1. is acceptable, can the pump in engine room be used for draining the original safety ballast tanks to which dangerous ballast tanks are connected?	Water in tanks deemed as dangerous ballast tanks cannot be led into the engine room.
3.	Can the chemical feed line be led from the engine room to the pump room?	May be allowed if the following conditions are satisfied: line is used only for feeding chemicals; small bore pipes are used; appropriate measures have been adopted against back flow; bulkheads between engine room and pump room are not penetrated by the line.
4.	Can FRP or GRP pipes be used in pipes in the ballast water treatment system?	To be studied using the Society's "Guidance for the Survey and Construction of Plastic Pipes."
5.	If "ballast water can be filled from tank deck position, and if a screw-down non-return valve (stop valve + non-return valve) is provided, ballast water can be filled in a dangerous ballast tank using a ballast pump in the machinery space (according to S.3.5.1-2 of the Society's "Guidance for the Survey and Construction of Steel Ships") in case of chemical tankers; can the same concept be applied to oil tankers also?	This is currently under examination, but there appears to be no clear reason for differentiating oil tankers and ships carrying dangerous chemicals in bulk with regard to safe ballast water and dangerous ballast water, so the same concept can be applied to oil tankers as well.
6.	Can the ballast water treatment system be installed in the engine room, treated water led into the pump room using a pump in the engine room (without penetrating the bulkhead between engine room and pump room) and filled each ballast tank from within the pump room?	At this moment, this is not allowed.
7.	What is the treatment of hazardous area for dangerous ballast piping?	The internal parts of dangerous ballast piping are treated as Zone 1 hazardous area. Accordingly even if dangerous ballast piping is led to a compartment in a gas-safe location, if there is no opening from the dangerous ballast pipe, the said compartment may be treated in principle, as a gas-safe location.