

Research Article

Ballast Water and Sediment Control and Management on Ship Using Method D-2: Auto Filter and UV Disinfection Treatment Methods

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Abstract: This study aims to protect the maritime environment from the spread of foreign species or harmful aquatic organisms and pathogens due to the discharge of ballast water from ships in order to prevent, minimize and completely eliminate risks to the environment, human health, wealth and resources arising from the transfer of aquatic organisms. harmful and pathogenic through the control and management of ballast water and sediment from ships, as well as to avoid unwanted side effects from such control and to encourage the development of related science and technology. The problems raised in this study are (1) What is the Ballast Water Exchange Standard (Reg. D-1), (2) What is the Ballast Water Performance Standard (Reg. D-2)?, (3) What is the Ballast Water Management Plan (BWMP) (Rule B-1) and (4) What is the combination of treatment technology. The method used in this research is descriptive qualitative method using data reduction analysis techniques, data presentation, and drawing conclusions as a method to determine the causes and efforts to overcome them. The results show that by applying the Ballast Water Performance Standard (Reg.D-2) with a combination of treatment technology, it can protect the maritime environment with the required ballast water performance standards. As required in the convention concerning the control and management of ballast water and sediment from ships/The International Convention for The Control and Management of Ship's Ballast Water and Sediments, 2004, in this convention it is required that ships of 400 gross tonnage and above are subject to this convention, not including floating platforms, FSUs and FPSOs are required to participate in the survey determined and meet the requirements of the BWM Convention. The conclusion of this study is that by installing BWMT to meet Reg. D-2 can protect the maritime environment from the spread of foreign species or aquatic organisms and pathogens.

Keywords: Ballast Water Discharge, Sediment, Aquatic Orgasm Transfer.

A. INTRODUCTION

In life since the existence of humans, sea transportation is very useful for the benefit of both business and transportation, according to the route and route. Related to the role of ships that are needed by every human being or the business world, every country has regulations that are applied by a country based on the condition of that country, one of which is a rule that requires the use of ballast, which includes the ballasting and deballasting process of a ship. The terms ballasting and deballasting processes are a process carried out to exchange seawater brought by ships from the loading port and will be exchanged at the loading port, so that the water brought from the loading port will be disposed of at the unloading port, where the sea water has the potential to carry organisms, pathogens, bacteria and sediment ballast from the loading port. In relation to this, each country together with the IMO regulation establishes several special regulations regarding ballast, among others, obliging every ship with international voyage or ocean-going ship to conduct ballast exchange. This is nothing but a

way to anticipate the ship so as not to carry organisms, aquatic pathogens, harmful sediment ballast bacteria from one country to another.

Meanwhile, to carry out the ballast exchange process, certain requirements such as location and sea depth are required. The ballast water convention promulgated by the International Maritime Organization (IMO) aims to minimize the risk of the entry of new species into other water areas to avoid the adverse effects of ballast water discharge. In some studies, it is said that Ballast water is water with substances contained in it which is carried aboard the ship to control the trim, slope, air flow, stability or pressure of the ship. Ballast water management is a process of mechanical, physical, chemical, biological, whether used alone or in combination, to remove, render harmless, or prevent the uptake or disposal of harmful aquatic organisms and pathogens from ballast water and sediments of a harmful organism. Hazardous aquatic organisms and pathogens are aquatic organisms or pathogens which, when introduced into the sea including estuaries, or into clean watercourses, can create damage to the environment, human health, wealth or resources, destroy biodiversity or mix with other legitimate uses of certain fields. While Sediment is a substance that is released from ballast water in a ship. Translated from English the International Convention for the Control and Management of Clean Water and Ship Sediments is a 2004 international maritime treaty that requires signatory flag states to comply with this convention. The convention requires all ships to implement a ballast water and sediment management plan. All ships must carry a ballast water log book and will be required to perform ballast water management procedures as defined by IMO standards. In ships, balance is needed, one of the roles of ballast water is water which is used as a ballast and a counterweight to the ship while sailing. When the ship carries out the ballasting and deballasting process, there will be an exchange of organisms in one area with another

This process goes on for years as long as the ship is in operation. This causes the balance of the ecosystem to be disturbed. Because the original organisms mixed with immigrant organisms which caused many genetic mutations to occur. Ballast water on ships plays an important role in improving ship stability, but has serious ecological impacts because many marine species are carried in ballast water. Marine species including bacteria, microbes, small invertebrates, eggs, cysts and larvae of various species present in ballast water taken from one water will disrupt ecosystems in other waters when the ballast water is discharged or removed from ships as well as prevention of water pollution. the sea through the process of filtering and cleaning ballast water so as not to pollute sea water in the port area where the ship is anchored. So important is the Ballast Water Management system in maintaining marine ecosystems.

From the background mentioned above, the formulation of the problem in this study are:

1. What is the Ballast Water Exchange Standard (Reg. D-1)?
2. What is the Ballast Water Performance Standard (Reg.D-2)?
3. What is the Ballast Water Management Plan (BWMP) (Rule B-1)?
4. What is the combination of treatment technology

B. LITERATURE REVIEW

The method used in implementing ballast water control: D1 (Sequential Method), this method can no longer be used and is replaced by applying D2 (Ballast Water Performance Standard).

1. Ballast Water Exchange (BWE)

Ballast water exchange is the process of exchanging coastal water, which can be fresh water, salt water, or brackish water, with water in the middle of the sea. During the exchange

process, the biologically laden water is taken at the final port and discharged from the ballast tank with open seawater, usually 200 nautical miles from the nearest land. Marine biologists, have determined that marine organisms and pathogens are, in general, less numerous in the open ocean and, due to changes in water chemistry, temperature and salinity will be less likely to persist after being dumped onto a nearshore receiving water. While most ships are capable of ballast water exchange, and the procedure usually does not require special structural modifications for the majority of ships in operation, this presents a challenge for designers, builders, owners, and operators. These challenges include over- or under-pressure tanks, longitudinal strength and transverse stability problems, and manoeuvrability issues.

There are three acceptable Methods for ballast water exchange namely (a) Sequential Method, (b) Flow-through Method, and (c) Dilution Method. Sequential Method is a process in which the ballast tank is emptied first and then refilled with replacement ballast water. Flow-through Method is a process by which replacement ballast water is pumped into a ballast tank, allowing the water to flow through an overflow or other arrangement. At least three times the tank volume must be pumped through the tank. Dilution method is a method whereby replacement ballast water is filled through the top of the ballast tank by simultaneous discharge from the bottom at the same flow rate and maintaining a constant level in the tank during the ballast exchange operation. At least three times the tank volume must be pumped through the tank.

2. Ballast Water Exchange Standard (Reg. D-1)

Ships performing Air Ballast exchanges shall do so with an efficiency of at least 95 per cent of Air Ballast volumetric exchange. For ships exchanging Ballast Air by pumping method, pumping through three times the volume of each tank of Ballast Air shall be deemed to comply with the standards described above. Pumping less than three times the volume is acceptable provided the vessel can demonstrate that at least 95 percent of the volumetric exchange is met.

3. Ballast Water Treatment

The effectiveness of ballast water exchange varies and depends on the type of vessel (design), method of exchange (Sequential Method, Flow-through Method and Dilution Method), ballast system configuration, exchange location, weather conditions and vessel's trading patterns. For these (and other) reasons, it has been determined that ballast water exchange does not provide adequate protective measures to prevent damage from organisms and pathogens carried in ballast vessels, although exchange is considered acceptable as a temporary solution. Ballast water treatment system installations (or ballast water treatment systems), are designed, reviewed, approved, installed and operated to meet agreed ballast water discharge performance standards set by the international marine industry to provide a more effective means of preventing, minimizing and ultimately eliminates transfer of organisms and pathogens via ship ballast release, when compared to ballast water exchange

The BWM Convention does not provide specific requirements regarding treatment methods. However, the maintenance equipment (system) must be type approved according to IMO guidelines. In addition, technologies utilizing active substances must also be approved by the relevant IMO committee (MEPC).

4. Ballast Water Performance Standard (Reg.D-2)

Vessels carrying out Ballast Water Management in accordance with this regulation are required to excrete less than 10 healthy organisms per cubic meter greater than or equal to 50 micrometres in the minimum dimensions and less than 10 healthy organisms per millilitre less than 50 micrometres in the minimum dimensions and greater of or equal to 10 micrometers in

minimum dimensions; and disposal of indicator microbes shall not exceed the concentrations described below:

Microbial indicators, as human health standards, include:

Toxicogenic *Vibrio cholerae* (OI and O139) with less than 1 colony forming unit (cfu) per 100 milliliters or less than 1 cfu per 1 gram (wet weight) zooplankton sample;

Escherichia coli less than 250 cfu per 100 milliliters;

Intestinal Enterococci less than 100 cfu per 100 milliliters.

Note: cfu – colony forming unit

Treatment Technologies.

Technologies currently available or under development can generally be grouped into three broad categories based on their primary mechanism for inactivating organisms as: mechanical, physical, and chemical.

a. Mechanical System

1). Filtration

Sediment and particulate matter are removed by disk and screen filters during ballast water filling. They often clean themselves with another rinse cycle. The waste stream is directed back out of the ship. This filtration system results in a reduced pressure drop and reduced flow rate due to resistance to filter elements and self-cleaning procedures.

2). Cyclone separation

The solid particles are separated from the water due to the centrifugal force. Only particles with a density greater than water can be separated.

3). Electro-mechanical separation

A flocculant is injected which sticks to the organisms and sediment. Magnetic separation and filtration are used to remove solid particles.

b. Physical Disinfection

1). Ultraviolet rays

UV radiation is used to attack and destroy cell membranes killing organisms directly or destroying their ability to reproduce. Its effectiveness depends on the turbidity of the ballast water (ie sediment concentration) as this may limit the transmission of UV radiation. UV lamps must be maintained and power consumption/requirements need to be considered

2). Cavitation / Ultrasound

A venturi pipe or slit plate is used to generate cavitation bubbles and the formation and collapse of these high energy bubbles produces hydrodynamic forces and ultrasonic oscillations, or high frequency noise, which disrupt the cell walls of organisms and effectively kill them.

3). De-oxygenation

Various methods are used to remove dissolved oxygen in ballast water and replace it with an inactive gas, such as nitrogen or other inert gas. Removing oxygen not only kills aerobic organisms but is also beneficial for corrosion prevention provided the oxygen content is maintained at the correct level. De-oxygenation takes a long time to get organisms and pathogens harmless to the receiving waters.

c. Chemical Treatment

1). Disinfect biocides

Pre-prepared or packaged disinfectants designed to be introduced into ballast streams and kill living organisms by chemical poisoning or oxidation. Typical biocides include chlorine, chloride ions, chlorine dioxide, sodium hypochlorite and

ozone. Residual biocides in ballast water must meet ballast disposal standards which may require neutralization techniques.

2). Electrolytic chlorination

An electric current is applied directly to the ballast water stream in the electrolytic chamber, generating free chlorine, sodium hypochlorite and hydroxyl radicals, causing electrochemical oxidation through the formation of ozone and hydrogen peroxide. This method has limited effectiveness in seawater which has a certain dissolved salt content and can also create unwanted residues. Types of chemical treatment include Active Substance or Preparation. The definitions given in the BWM Convention are as follows:

- a). Active substances - Substances or organisms, including viruses or fungi that have general or specific action against or against harmful aquatic organisms and pathogens.
- b). Preparations - All commercial formulations containing one or more active substances including additives. The term also includes any active substance produced on board ships for the purpose of ballast water treatment and related chemicals formed in a ballast water treatment system that uses the active substance to comply with the BWM Convention.

5. Ballast Water Treatment System

The important characteristics of the treatment methods for ballast water treatment systems, which are currently offered in the market are given below. It should be noted that some ballast water treatment systems that use chemical biocides or de-oxygenation may require additional treatment before the water is discharged into receiving waters.

6. Combination of Treatment Technology

Treatment technologies can be combined and differ in rate of application, holding time, power consumption and effects on equipment or other ship structures. The combination of different treatments can reduce individual technological limitations. Therefore, many ballast water management systems (BWMS) use a combination of two or more technologies, e.g. filtration combined with UV, filtration combined with chemical injection/electrochlorination, etc.

Upon entry into force of the Convention, newly constructed vessels shall, (without compromising safety or operational efficiency), be designed and constructed with a view to minimizing unwanted sediment uptake and entrapment, facilitating sediment disposal, and providing safe access to allow sediment removal and sampling. (Rule B-5 of the 2004 BWM Convention). The G-12 Guidelines should be adhered to as far as possible.

Both new and existing vessels will be required to have procedures applicable to ballast water operations for sediment control. The recommendations given in Guidance G4, Part A, Section 1.3, should be adhered to as far as possible.

Details of operational methods and procedures for onboard sediment management, including sediment disposal and related safety considerations, etc., should be documented in the ship's BWMP

Every ship is required to have and implement a Ballast Water Management Plan (BWMP). The plan shall be approved by the Administration/RO on behalf of the Administration, if permitted, taking into account the Guidelines (G-4) developed by IMO.

BWMP made specifically for each ship and must at least:

- a. outlines detailed safety procedures for ships and crew related to BWM as required by the Convention;

- b. provide a detailed description of the actions to be taken to implement the BWM requirements and additional BWM practices as provided for in the Convention;
 - c. outlines procedures for sediment disposal: both at sea; and on land
 - d. include procedures for coordinating the BWM of ships involving discharges at sea with the authorities of the State in whose waters the disposal is to be carried out;
 - e. appoint an officer who is responsible for ensuring that the plan is carried out properly and make a list of tasks;
 - f. contains reporting requirements for vessels regulated under the Convention; and
 - g. written in the ship's working language. If this language is not English, French, or Spanish, a translation into one of these languages is required BWMP includes training and education for crew on BWM practices and the systems and procedures used in the ship Periodic reviews of the Plan by the owner, operator or master should be carried out to ensure that the information contained is accurate and up-to-date. A feedback system will be used which will allow rapid retrieval of changing information and its incorporation into the Plan.
 - h. Changes in the provisions of BWMP need approval from the Administration (Ditkapel & BKI)
 - i. The following conventions, guidelines and rules should be carefully considered, where applicable, for the development of BWMPs:
 - j. A ballast water management plan should be developed based on the G4 guidelines adopted through MEPC.127 (53). However, if the BWMP has been approved in accordance with resolution A.868 (20) prior to the entry into force of the BWM Convention, the same will remain in effect until the plan requires revision due to the installation of a ballast water management system. Revised BWMP in accordance with the Convention must be approved in accordance with the latest IMO Guidelines (G-4) i.e. as per resolution MEPC.127 (53).
- Ballast Water Record Book (BWRB) (Rule B-2)
- a. Each ship must have a Ballast Water Registry (BWRB) which can be in electronic form, or integrated into other systems or books and must contain at least the information specified in Additional Annex II to the Convention.
 - b. Records of the BWRB must be kept on board the vessel for a minimum period of two years after the last entry was made and thereafter in the control of the Company for a minimum period of three years.
 - c. All Ballast Water discharge according to Reg. A-3, A-4 or B-3.6 of the Convention, and/or including accidental or extraordinary waivers, which are not excluded by the Convention, shall be recorded, without delay in the BWRB. The circumstances and reasons for the return should also be stated.
 - d. If exceptions or exceptions have been granted to vessels, vessel owners and operators must ensure that they are properly documented and entered into the BWRB. It should be noted that exceptions are situation specific, therefore record keeping and communication is the only way to demonstrate compliance. The BWRB must be available for inspection at all times and, for unmanned vessels being towed, may be stored on the tugboat.
 - e. Every operation regarding ballast water must be fully recorded immediately in the ballast water record book. Each record must be signed by the officer in charge of the relevant operation and every completed page must be signed by the master. The recording of the ballast water log book is mandatory in a ship's work discussion. If the language used is not English, French or Spanish, the note must contain a translation

into one of these languages. If the record uses the national language of the country of the ship's flag, this must apply in the event of a dispute or conflict

- f. Officials authorized by a participating country may check the ballast water record book on board each ship where this regulation applies when the ship is in its port or offshore terminal, and can make a copy of each record, and ask the master to legalize the copy. Each certified copy shall be admissible at every court hearing as tangible evidence stated in the records. Checking the ballast water record book and taking a certified copy must be carried out quickly and efficiently so as not to cause the ship to be unnecessarily delayed.

C. METHODS

The method used in this research is a qualitative method that focuses on in-depth observations in order to produce a more comprehensive study of a phenomenon through the phenomenon to be studied. (1) raised the issue. (2) raises research questions., (3) Collects relevant data, (4) Performs data analysis. And (5) Answering research questions. In relation to this research, the researchers used the following steps: (1) Determine the vessel that is possible for observations, (2) Fill ballast water into the specified vessel, (3) Observe the level of pollution in the water. sea, (4) Observing the effectiveness of Ballast watering management in controlling marine pollution, (5) Conducting studies with relevant research, (6) Analyzing the level of pollution and (7) Answering this research question.

D. RESULTS AND DISCUSSION

To Fulfillment of convention by installing BWMT, BWM Method: D2 (Auto filter and UV disinfection treatment methods), manufacturer: SHANGHAI CYECO ENVIROMENTAL TECHNOLOGY CO., LTD)-CHINA

1. System Components

Cyeco™ BWMS consists of a two-stage process, namely by applying efficient automatic filtration to remove larger organisms and sediment followed by a powerful medium pressure UV unit to disinfect and inactivate smaller plankton, bacteria and pathogens, according to IMO standards. D-2. The medium pressure UV device, adopted by Cyeco™ BWMS, has significant advantages in marine applications in addition to its physical properties in the process. It requires a minimized footprint due to its compact design, which makes it easy to fit into any vessel especially those with limited space available.

System Features:

- a. Completely chemical free process
- b. Compact design and minimized footprint
- c. Automatic Operation & 100% Safe
- d. Attention Minor Surgery & Minimum Maintenance Required
- e. Less drainage & waste sediment

Cyeco™ BWMS is Composed of:

- f. Automatic high pressure self-flushing filter (Located in the explosion-proof area)
- g. Medium pressure ultraviolet (UV) unit (Located in the explosion-proof area)
- h. High pressure pump (Located in the explosion-proof area)
- i. Piping & Valves (Located in the explosion-proof area)
- j. System Bracket (Located in the explosion-proof area)
- k. Control System (Located in the safety area)
- l. Power Panel (Out of the skid Located in the safety area)



Fig.1-1: Cyeco-BWMS

Cyeco-BWMS Skid

The Cyeco™ BWMS (UV filter and reactor) is integrated into the ballast water system and so that proper treatment occurs automatically in the ballast and de-ballasting.

Ballast water is treated through a complete process (filter followed by UV reactor) at the ballast water intake and reprocessed at exhaust only through the UV reactor (filter is bypassed). The UV irradiation of the ballast water again during de-ballasting ensures that any bacterial regrowth that may occur in the ballast tank is fully disinfected prior to disposal. The related automatic valve switching is controlled and completed by PLC automatically.

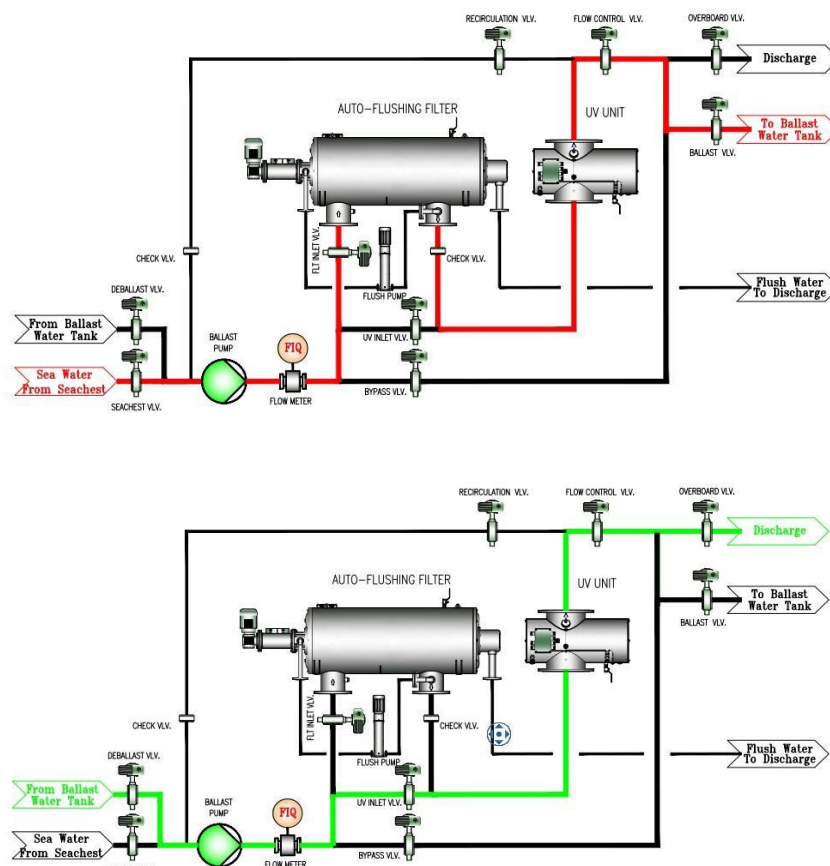


Fig.1-3: /De-ballasting (green line)

2. Technical Specification

Model: Cyeco-B300 (Ex)

Supply Voltage: AC380V/3P/50Hz

Ballast pump capacity: ~ 300 m3/hr

BWMS Treatment Capacity: ~300 m³/hr
Power Consumption in Total: 42.5Kw
Pressure Loss: 0.2 ~ 0.3 bar
Skid outline Dimension: 2488 (L) x 1000 (B) x 1923 (H) mm

High pressure Back-flushing filter

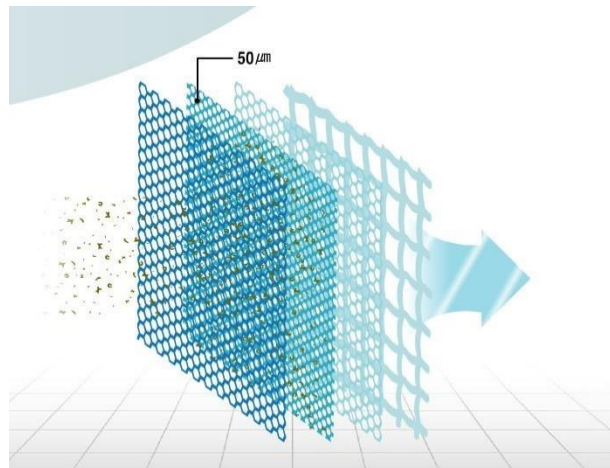


Fig.2-2: 3D Model Filters

The filter is designed to automatically backwash itself at the end of each ballast or ballast removal operation, and when a timer is triggered or a preset differential pressure caused by solids forming on the filter screen is reached



Fig. 2-3: UV Unit

Composed of:

- 1) filter body:316LSS
50um/fine screen:316LSS
- 2) Cleaning motor (440V/3P/60Hz:0.75kW);
- 3) Reducers;
- 4) Limit switch;
- 5) Junction box;
- 6) Differential pressure switch.
- 7)

Filter Specification:

Model: Cyeco-CF300

Flow rate: ~300 m³/hr

Filtration grade: 50 micron
High pressure back flushing: 4m³/hr
Power consumption of flushing pump: 7.5 kW
Design pressure: 8 bar
Max. working temperature: 55°C
Dimension(mm): 620 x 2060 (H) mm

UV Unit

The medium pressure lamp used by Cyeco™ BWMS produces a polychromatic UV output across the entire germicidal curve spectrum. As such, the medium pressure UV device is robust enough to handle the very high flow rates with the very small footprint required. Noting Therefore, medium pressure UV is best suited for ballast water treatment applications, which have to face various challenges of poor water quality in addition to high flow rate demands.

Composed of

- 1) UV body, 316LSS; 2) UV Lamps with quartz sleeve
- 2) UV lamp self-cleaning device; 4) Temperature Sensor
- 3) UV intensity sensor; 6) Junction Box

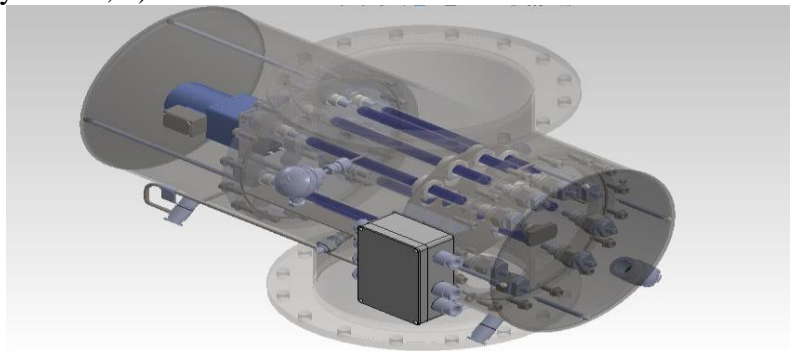


Fig. 2-4: Medium Pressure Ultraviolet 3D Perspective

UV Specifications

Models:

Cyeco-CU300(Ex)

Capacity: ~300m³/hr

Design pressure: 8 bar

Operational water temperature: < 45°C

Protection degree: IP54

Dimension(mm): 940 (L) x 410 (B) x 580 (H)mm

Lamp Life Time: 5000~8000Hr

Lamp Supplier: European

Power Panel and Control Panel

The entire Cyeco™ BWMS is controlled by a PLC control panel (programmable logic controller) with a touch screen built into it. The PLC system monitors and controls all components (filters, UVs, automatic valves, if needed) and keeps the UV units working at optimal status.

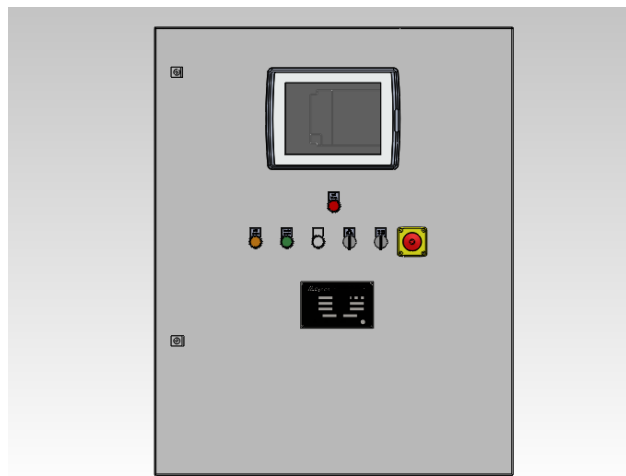
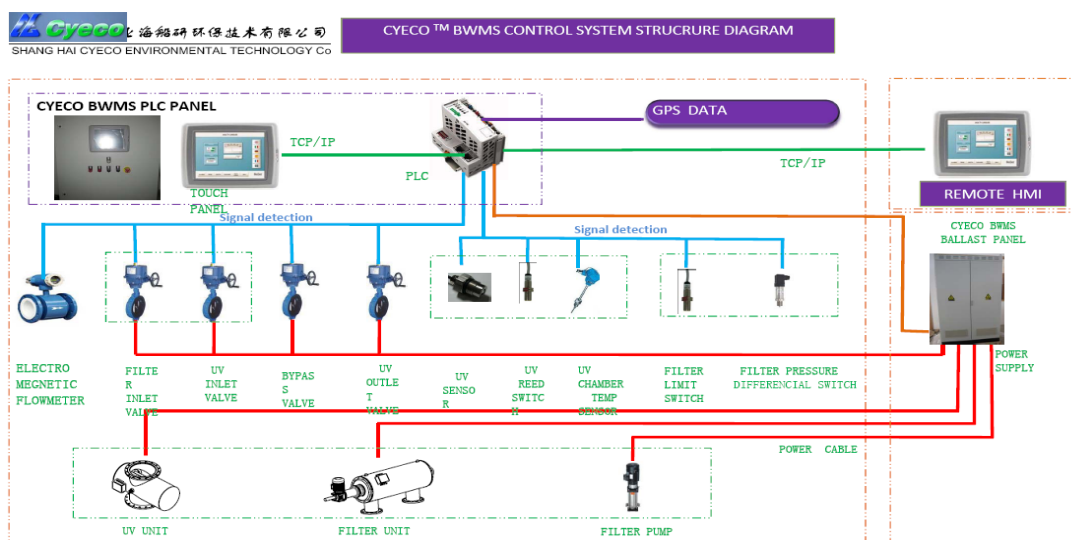


Fig. 2-5: PLC Control Panel

Including: (1) Panel; (2) Touch screen; (3) System nameplate; (4) Power indicator; (5) Operation and fault indication; (6) switch; (7) Emergency stop button; PLC and control components.

Automatic meters monitor flow, pressure, temperature and UV irradiation intensity, relay signals to PLC for system control and alarms. and through the touch screen interface, you can complete system control and related operations, including:

- Data collection
- System Valves Control
- System Flow Adjustment;
- Ballast/De-ballast System Operation;
- Parameters and Fault Display;
- Data Records and Historical Data Query;
- Data Processing;
- Data Communications;
- Remote Operation
- GPS signal Data Transmission;



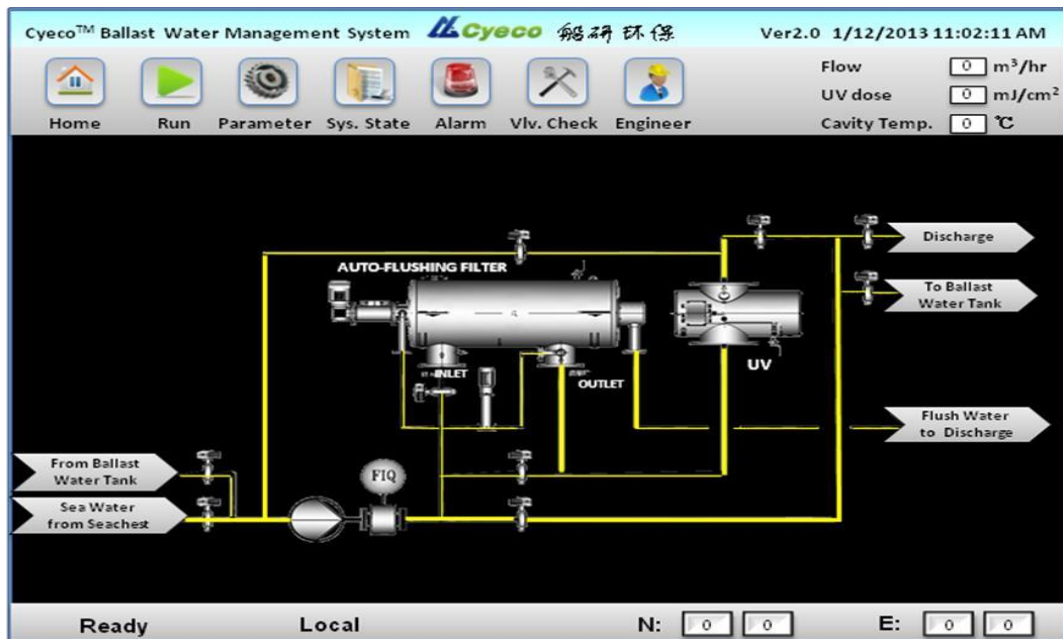


Fig.2-7: Cyeco BWMS In-touch Screen

Monitored on the touch screen about all ballast water treatment system conditions including:

- Automatic back-flushing of filter
- UV running status / UV running status
- Logging status of system / System logging status
- Valve control / control valve
- Alarm messages:
 - * Low flow rate alarm (low flow alarm)
 - * Temperature alarm for UV chamber (temperature alarm for UV Chamber)

Operational temperature (operational temperature): 0~55°C

Electrical supply (power supply)

- Voltage: AC 440V
- Phase: 3 Phase
- Frequency: 60Hz

GPS signal input: RS422/NEMA-0138

Remote communication port: RJ45

Remote communication protocol: Modbus TCP/IP

PLC control panel dimension: 700 (L) x 300 (B) x 1300 (H)mm

Power panel dimension: 1300 (L) x 600 (B) x 2000 (H)mm

Material: Epoxy coated

Colour: Approved drawings confirmed

Protection IP54

Located in safety area (Engine room)

The ballast water that goes through this BWMT has met the performance standards according to the D-2 regulation

E. CONCLUSION

From the results of observations and analysis, it can be concluded that (1) the Ballast Water Exchange Standard (Reg. D-1) is no longer permitted for now and has been replaced with D-2, (2) Ballast Water Performance Standards/Ballast Water Performance Standard (Reg.D-2). Vessels carrying out Ballast Water Management in accordance with this regulation

are required to excrete less than 10 healthy organisms per cubic meter greater than or equal to 50 micrometers in minimum dimensions and less than 10 healthy organisms each milliliter is less than 50 micrometers in the minimum dimensions and greater than or equal to 10 micrometers in the minimum dimensions; and removal of indicator microbes must not exceed concentrations, (3) Combination of Treatment Technologies may be combined and differ in application rate, holding time, power consumption and effects on equipment or other ship structures. The combination of different treatments can reduce individual technological limitations. Therefore, many ballast water management systems (BWMS) use a combination of two or more technologies, e.g. filtration combined with UV, filtration combined with chemical injection/electrochlorination.

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