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BALLAST WATER TREATMENT SYSTEM A METHOD TO PROTECT THE ENVIRONMENT

Mihail-Vlad VASILESCU, A.I. Epikhin

In order to prevent ecological and environmental disasters resulting from the discharge of ballast water, in 2004 was adopted Ballast Water ManagementConvention. According to the regulation, ballast water exchange must be conducted at least 200 nm from the nearest land and in waters at least 200 m in depth or in cases where the ship is unable, at least 50 nm from the nearest land and in water at least 200 m in depth or in a designated ballast water exchange area in accordance with the regulation.For costal ships, with are not going far away from shore is almost impossible to comply with D-1 and D-2 standards. For this reason appeared Ballast water treatment system (BWTS).This system neutralizes organisms in the water. International Convention for the Control and Management of Ship's Ballast Water and Sediments sets the rules for ballast water treatment in around 95% of the world's ports. Since 28 October 2020, IMO revised G8 guidelines for type approving ballast water treatment systems went into effect. The ballast water treatment system must be approved by a classification

society, after that it is ready to comply.The system has to be operated and maintained according to the regulations and supplier's specifications. This article major points are: Methods of doing ballast water exchange, Ballast water treatment system, System components description
Keywords: ballast water, environment, ballasting, deballasting, filter

СИСТЕМА ОЧИСТКИ БАЛЛАСТНЫХ ВОД – МЕТОД ЗАЩИТЫ ЭН-ВИРОНМЕНТА

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В целях предотвращения экологических и экологических катастроф, возникающих в результате сброса балластных вод, в 2004 году была принята Конвенция по управлению балластными водами. Согласно регламенту, замена балластных вод должна производиться на расстоянии не менее 200 морских миль от ближайшего берега и в водах глубиной не менее 200 м, а в случаях, когда судно не в состоянии, не менее 50 морских миль от ближайшего берега и в воде не менее 200 м в глубину или в специально отведенном для этого пункте замены балластных вод в соответствии с регламентом. Для прибрежных судов, не уходящих далеко от берега, практически невозможно выполнить нормы Д-1 и Д-2. По этой причине появилась система очистки балластных вод (ОСВО). Эта система нейтрализует находящиеся в воде организмы. Международная конвенция по контролю и управлению судовыми балластными водами и осадками устанавливает правила обработки балластных вод примерно в 95% портов мира. С 28 октября 2020 года вступили в силу пересмотренные руководящие принципы IMO G8 для систем очистки балластных вод, утверждающих тип. Система очистки балластных вод должна быть одобрена классификационным обществом, после чего она готова соответствовать требованиям. Система должна эксплуатироваться и обслуживаться в соответствии с правилами и спецификациями поставщика. Основные моменты этой статьи: методы замены балластных вод, система очистки балластных вод, описание компонентов системы.
Ключевые слова: балластная вода, окружающая среда, балласт, дебалластировка, фильтр.

1. Introduction

Ballast water exchange is a process which involves the substitution of water in ship's ballast tanks using either a sequential, flow-through, dilution or other exchange methods which are recommended or made obligatory by the IMO, in order to preserve ecology in biologically rich coastal waters and similar to those in deep oceanic waters.

A Port State may designate areas where ballast water exchange may be conducted if there are locations of operation where the distance from nearest land and water depth do not meet the requirements: of at least 200 nm from the nearest land and in waters at least 200 m in depth or in cases where the ship is unable, at least 50 nm from the nearest land and in water at least 200 m in depth or in a designated ballast water exchange area in accordance with the regulation.

This regulations appeared because marine organisms and/or pathogens taken on in coastal waters are less likely to survive when discharged into the open ocean due to changes in the water's chemistry, temperature and salinity, and similarly, those organisms taken onboard in oceanic waters are less likely to survive in coastal waters. Ballast Water Exchange (BWE) is required to be carried out during the vessel's voyage through various zones of the seabed.

2. Methods of doing ballast water exchange

2.1 Sequential method: In this process, the ballast water tank is first emptied and then refilled with replacement ballast water to achieve at least a 95 per cent volumetric exchange. All of the ballast water in each tank should be discharged until suction of the pumps is lost and stripping pumps or eductors should be used if possible, to avoid a situation where organisms are left in the bottom of the tank, the tank is then refilled with new water. Emptying of tanks can be done individually or in pairs.

2.2 Flow-through method: The flow-through method is a process by which replacement ballast water is pumped into a ballast tank intended for the carriage of ballast water, allowing water to flow through overflow or other arrangements in order to achieve at least 95 per cent volumetric exchange of ballast water. Pumping through three times the volume of each ballast water tank shall be considered to meet the standard regulation.

2.3. Dilution method: The dilution method is a process by which replacement ballast water is filled through the top of the ballast tank intended for the carriage of ballast water with simultaneous discharge from the bottom at the same flow rate and maintaining a constant level in the tank throughout the ballast exchange operation [1, 2].

3. Ballast water treatment system

In order to avoid all the above methods and to comply with the regulations there has appeared different types of Ballast water treatment system.

3.1 Components

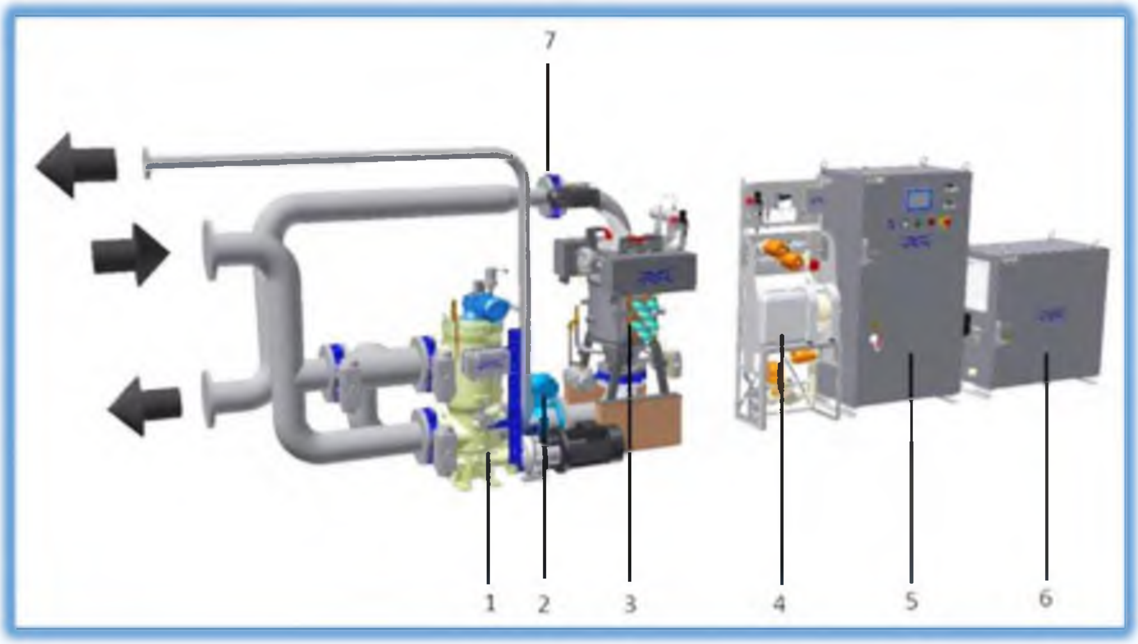

Figure 1 – Ballast water treatment system components:
1. Filter; 2. Flow meterwith conductivity sensor; 3. UV reactor; 4. CIP (cleaning-in-place) module; 5. Electrical cabinet (EC); 6. Lamp drive cabinet/cabinets (LDC), not included in all system sizes; 7. Control valve

During ballastoperation, the water is led through the filter, which removes larger particles and organisms, and then to the UV reactor, where the water is treated with UVlight. During deballast, the water is led the same way, but the filter isbypassed.Flow is monitored by the flow meter and regulated by the control valve. After operation, the UV reactor is cleaned by a CIP (cleaning-in-place)process.The complete system and ongoing processes is controlled and monitored fromthe electrical cabinet.Control can also be performed from remote control panels and the ship'sISCS, via the remote interface if connected.The bypass valve makes it possible to bypass the entire system.

3.2 Start-up phase

Ballasting and deballasting begins with a start-up phase. During start-up, theUV lamps are warmed up for 90 seconds.

The temperature transmitter and level switch secure that there is water in theUV reactor and that the UV lamps are sufficiently cooled. If the temperature inthe UV reactor reach 38°C, cooling water (technical water / potable water) ispumped through the UV reactor to secure that the UV lamps are notoverheated.

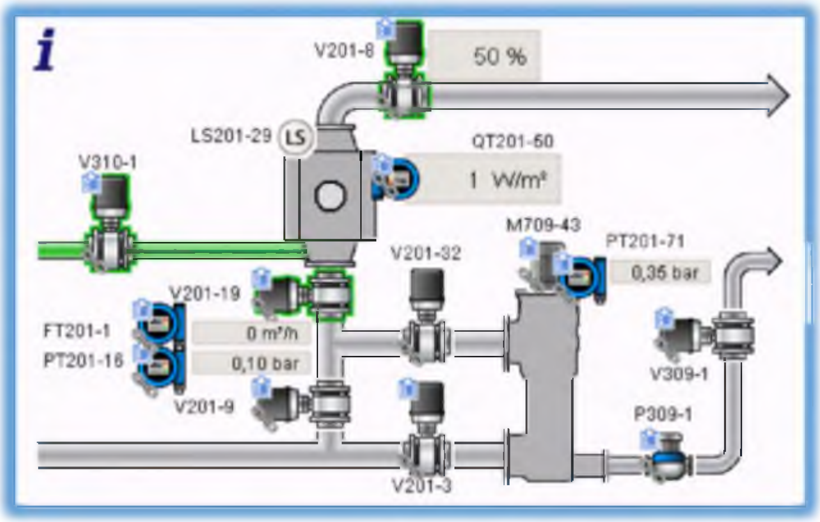

Figure 2 – Ballast and deballast start-up

3.3 Ballasting

After the start-up, when the lamps are ready, the operator is requested to startthe ballast pump. The ballast water is pumped from the sea chest to the filter, that removes larger particles and organisms. This also reduces the amount ofsediment build-up in the ballast water tanks [3]. The organisms and sedimentscaught in the filter are flushed overboard via regular filter backflush operations.The water is finally led to the UV reactor, which produces radicals and UV lightthat breaks down and neutralize the organisms.

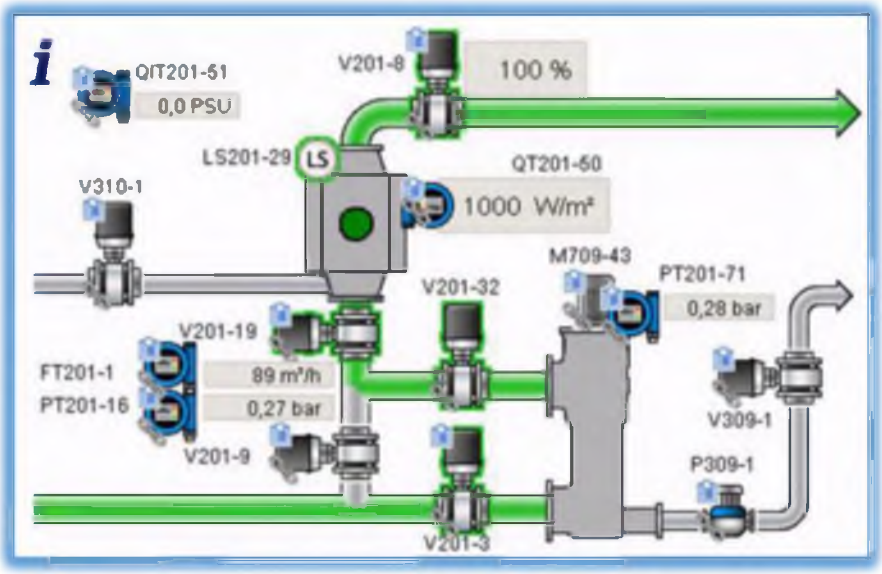

Figure 3 – Ballasting

3.3.1 Backflush

To keep the filter clean, it is automatically backflushed. The backflush isperformed during ongoing process without interrupting the ballasting process.When a ballast operation is stopped, a backflush is performed before the system comes to a full stop. The ballast water used for backflushing isreturned to the sea directly at the ballasting site.

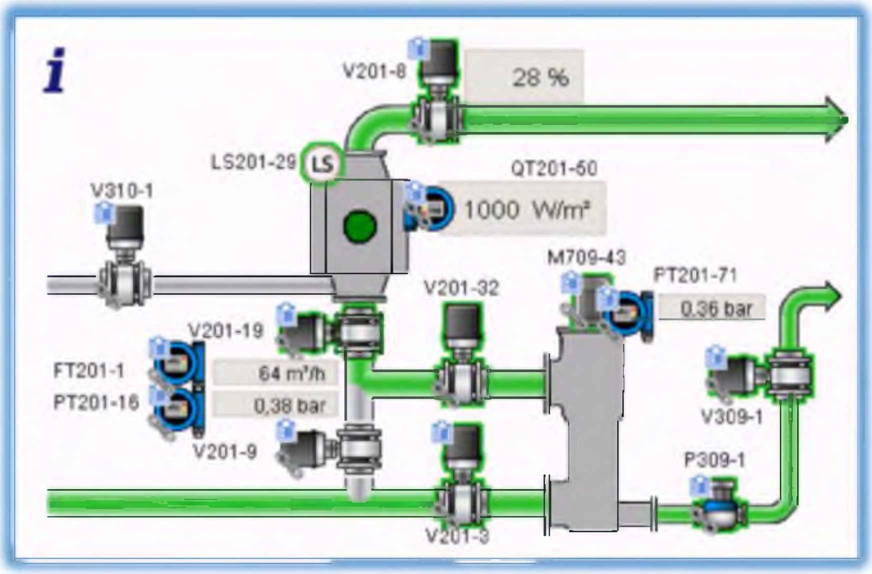

Figure 4 – Filter backflush

3.3.2 Ballast after-treatment (CIP process)

After a ballast operation, a CIP (cleaning-in-place) process is performed toclean the UV reactor. This process can either be performed immediately aftera ballast operation or started within 30 hours counted from when the process was started[4,5].The UV reactor and filter are rinsed with technical water / potable water. Then, the UV reactor is filled with biodegradable CIP liquid and technical water /potable water, which is circulated periodically, approximately four times perhour, during the 6 hours CIP process to remove scaling from the quartzsleeves and

UV sensor glass. After the cleaning is finished, the UV reactor isfilled with technical water / potable water to prevent scaling, algae growth etc.

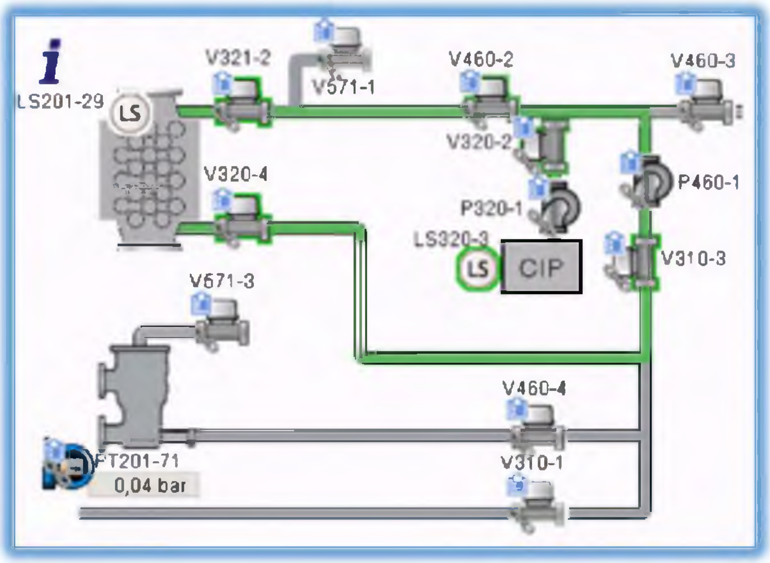

Figure 5 – CIP circulation during CIP process

3.4 Deballasting

Deballast use the same start-up process as during ballast. After the start-up,when the lamps are ready, the operator is requested to start the ballast pump.The water passes through the UV reactor, but the filter is bypassed since the water has already been filtered during ballasting. The reason for treating thewater a second time during deballasting is to secure that the treatment is fullyeffective. The minor part of the organisms, which were only injured during ballast, will be rendered totally harmless during the deballast.The flow control and power optimization functions in the same way as duringballasting.

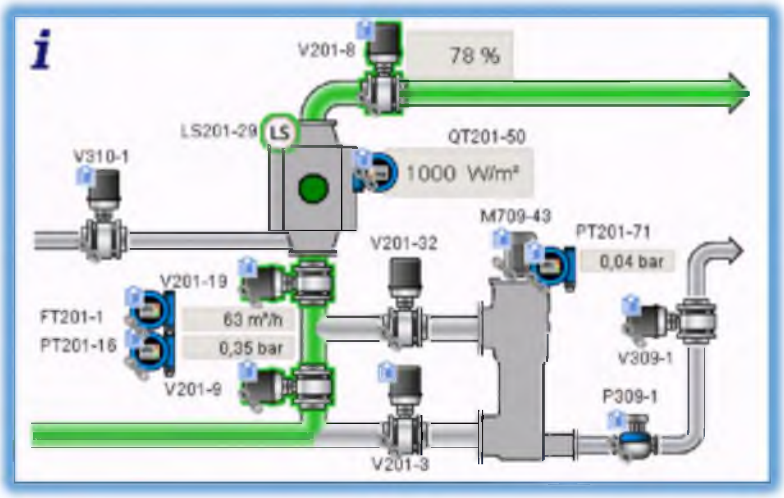

Figure 6 – Deballasting

3.4.1 Deballast after-treatment (CIP process)

As after ballasting, a CIP process is performed after a deballast operation.

3.5 Tank stripping

Stripping can be performed to empty the ballast tanks. A stripping process issimilar to a deballast process; in both processes the filter is bypassed.

After the start-up, when the lamps are ready, the operator is requested to starta stripping pump. Pump used can either be a dedicated stripping pump or aballast water pump. Power optimization is not active. Minimum flow includes the driving water.

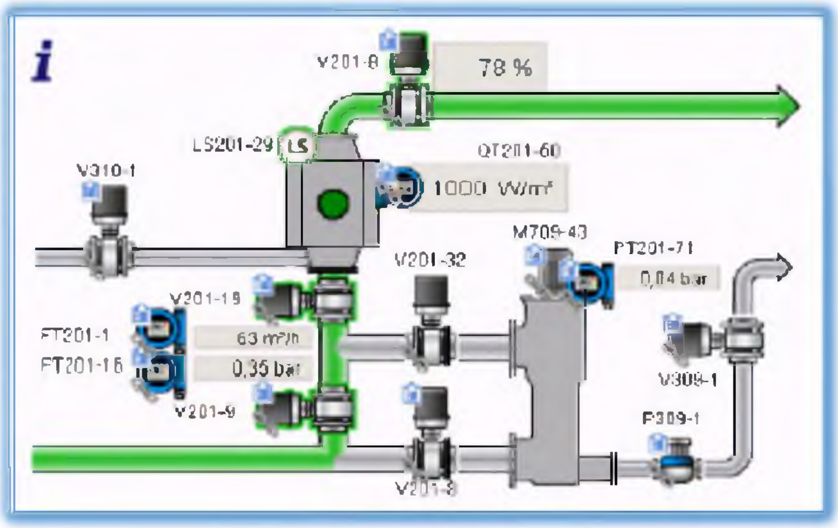

Figure 7 – Stripping

3.5.1 Stripping after-treatment (CIP process)

As after ballasting, a CIP process is performed after a stripping operation.

3.6 Ballast water handling in the event of malfunction

In case of malfunctions it is possible to bypass the system. According to the BWM Convention, the system must beequipped with at least one bypass valve. The valve(s) must be controlled bythe control system of the vessel [1,6]. Allbypass valve activities are logged in the event log.Several combinations of valves can be used to bypass the system. Accordingto legislations, all bypass configurations must be monitored – both those thatare driven by pumps and by gravity.

4. System components description

4.1 UV reactor

The main part of this BWTS is the UV reactor.

4.1.1 UV reactor working principle

The main treatment process take place inside the UV reactor, where themicoro organisms in the water is exposed to UV light, which renders them-completely harmless.The UV light breaks the DNA chain resulting in an internal connection (T+T)making it impossible for the micro organisms to reproduce.

Figure 8 – Destruction of DNA (Before UV treatment and After UV treatment)

There are no chemical substances added to the process, and there are notoxic residuals created. Since the water is not affected chemically, there are noenvironmental impact and the process does not influence corrosion in anyway.

4.1.2 UV reactor description

The UV reactor consist of the reactor, sensors and valves for water and CIPliquid, as shown in the illustration below. The UV reactor accommodates 16medium-pressure UV lamps (6 kW each).

The UV lamps are enclosed in individual quartz-glass sleeves.The UV lamps get very warm, so they must be cooled whenever they are lit.To secure that there is water in the reactor when the lamps are lit, the reactoris equipped with a level switch. The level switch also secures that enough CIPliquid is pumped into the reactor during the CIP process. To secure that thelamps are adequately cooled by the ballast water, the UV reactor has a threefold heat protection:

Level 1: The temperature transmitter sends information to the control system.The UV reactor is shut down at 60 °C.

Level 2: The temperature transmitter sends information to a safety relay in theEC. The UV reactor is shut down at 62.5 °C.

Level 3: The temperature switch automatically shuts down the UV reactor at 65 °C.

A UV sensor monitors the UV lamp efficiency in relation to the watertransmittance inside the UV reactor. Based on this input, the power to the UVlamps are regulated between 50 and 100 % of full capacity. To save power, theUV lamps will be dimmed to lowest possible level, where they are stilleffective.

4.1.3 Main components for the UV reactor

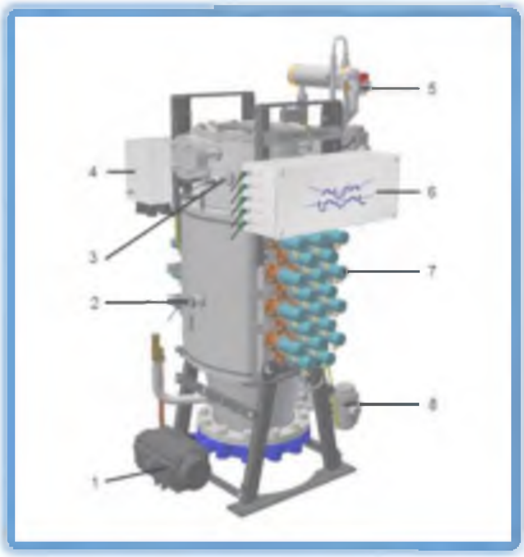

Figure 9 –Main components for the UV reactor:
1. Inlet valve; 2. UV sensor; 3. Level switch; 4. Control box; 5. Regulator, air; 6. Junction box; 7. UV lamp cap (UV lamp an quartz sleeve inside); 8. CIP service valve

4.2 Filter

The filter is a fully automatic self-rinsing component, equipped with a filterelement to remove particles and organisms from the ballast water flow. Theballast water is lead through the filter, and filtered particles are trapped in thefilter.

4.2.1 Filter main components

4.2.2 Filter description

To secure efficient filtration, the filter performs a self-rinsing backflushoperation at time set intervals or when triggered by indication of dirt in thefilter. Pressure drop over the filter is monitored by pressure transmitters on thefilter inlet and outlet. Dirt is detected by an increased differential pressure dropcaused by particles in the filter. When the differential pressure reaches aparameter set value, an automatic backflush operation starts.

The backflushing does not interrupt the filtration process, since only a part ofthe filter element area is cleaned. The areas that are not cleaned at a specifictime continues the filtration of the ballast water. It is also possible to start backflush manually from the control system.

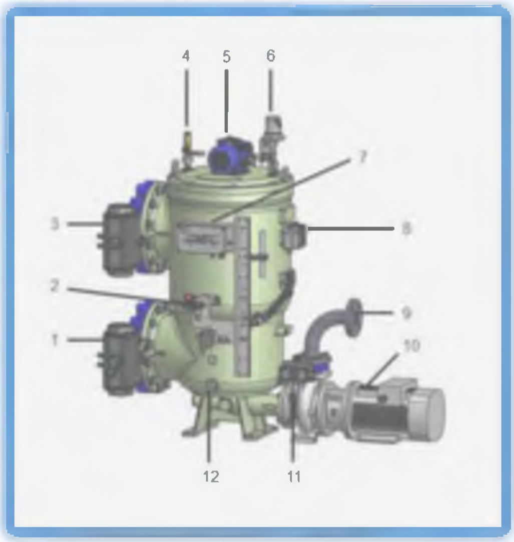

Figure 10 – Filter main components:
1. Inlet valve; 2. Regulator, inlet air; 3. Outlet valve; 4. Relief valve (overpressure); 5. Geared motor; 6. Automatic de-airiation valve during filling and a PLC-controlled valve for letting airin during draining; 7. Junction box; 8. Valve block; 9. Backflush outlet; 10. Backflush pump (optional); 11. Backflush valve; 12. Drain plug

4.3 CIP (cleaning-in-place) module

The purpose of the CIP (cleaning-in-place) process is to clean the quartzsleeves covering the UV lamps and the UV sensor. This will ensure that theUV light will treat the water efficiently and that the flow control and poweroptimization functions, based on correct input from the UV sensor.

After the UV reactor (and filter, when CIP is done after ballast) is drained fromsea water, the UV reactor and filter is filled with technical water / potablewater. The UV reactor is filled with 1 l concentrated CIP liquid to the UV reactor. The low-pH CIP liquid removes scaling, calcium chlorides, metal ionbuild-up and chemical fouling on the lamps quartz glass sleeves. The mixedCIP liquid is left in the UV reactor for 6 hours.Approximately four times per hour, the CIP liquid is circulated to improve thecleaning efficiency. As a last step, the UV reactor is filled with technical water /potable water to prevent scaling, algae growth etc.

4.3.1 CIP module main components

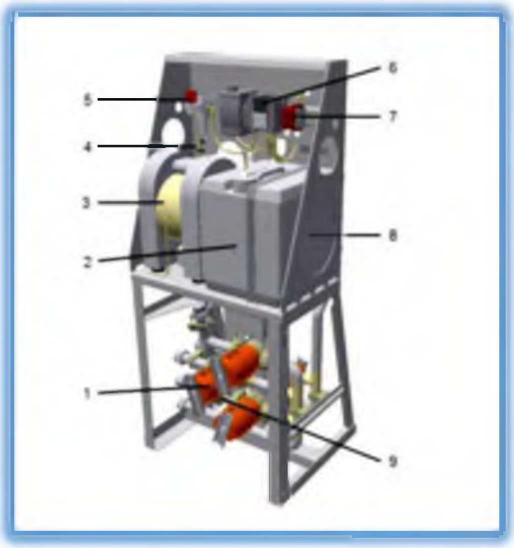

Figure 11 – CIP module:
1. Service valve (5 pieces); 2. Container CIP concentrate; 3. Pump P460-1, drain and circulation; 4. Regulating valve for diaphragm pump P460-1; 5. Regulator, air; 6. Valve block; 7. Dosing pump P320–1 for CIP concentrate; 8. Level switch (sensor low); 9. Check valve

4.4 Electrical cabinet

The electrical cabinet (EC) is equipped with the control panel, which is used tocontrol and monitor the system. The cabinet is equipped with an emergencystop button, an audible and visible alarm indication and USB ports for softwareupload and log file export. Lamps on the cabinet indicates if power is on, UVlamps are lit and if the cabinet needs to be reset after a shutdown or power off.The electrical cabinet is also fitted with 5 lamp power supplies (LPS), whichare feeding power to the UV lamps [1].

4.4.1 Electrical cabinet with main control panel

Figure 12 – Electrical cabinet with main control panel:
1. Main breaker; 2. Main power cable; 3. Main control panel; 4. Lamp power cable to UVR; 5. Signals to LDC 1

4.5 Control system

The control system is used to set parameters, operate and monitor theBWTS. The control system continuously monitor BWTS (sensors, communication and PLC status), both during operation and instandby mode. Any deviation is either communicated to the operator orhandled automatically, based on parameter settings. Safety risks are alwayshandled automatically.

4.6 Main valves

The main valves in the system are:

- Filter inlet valve
- Filter outlet valve
- Filter bypass valve
- UVR inlet valve
- Control valve
- Technical water / potable water valve
- BWTS bypass valve

4.7 Flow meter

The flow meter has two functions:

- Monitor flow
- Monitor conductivity.

4.7.1 Monitor flow

The flow meter monitor the flow within the BWTS, to secure thatcertified flow is not exceeded. If so, a warning is issued. The flow meter sendvaluable data to the ballast control system, where it is displayed.

4.7.2 Monitor conductivity

The flow meter measure conductivity in the water. This information is usedtogether with temperature to calculate salinity in the water.

4.8 Pressure monitoring

Two pressure transmitters monitor the pressure in the system.

4.9 Vacuum relief valves

If the BWTS is placed high up in ship's pump rooms or even ondeck in a deckhouse the fall height in the downward going pipes between theBWTS and the tanks/overboard can be considerable. Wheneverthe water in the pipes free fall in downward going pipes the pressure upstreamwill be affected and low pressure will appear. Depending of the geometry ofthe system the low pressure can be considerable and can potentially causecavitation and pressure waves which is harmful to the BWTS installation.

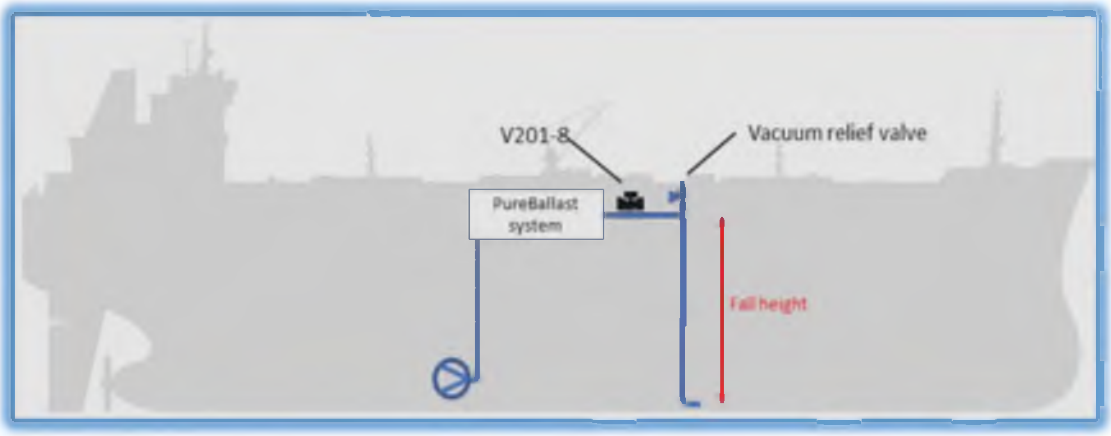

Figure 13 – Ballast systemoverview

To solve the problems with cavitation and vacuum, the system should beequipped with vacuum relief valves:

- **VB201** In pipe 201. Float operated vacuum relief valve providing both air releaseupon startup of the system and vacuum relief during operation.
- **VB309**In pipe 309. Only vacuum relief, without air venting function. The valveis spring loaded (normally closed) to avoid water spillage during initiationof back-flush.

5. Conclusion

In order to prevent ecological and environmental disasters, ship owners must comply with the Ballast Water Management Convention.

The article shows that one of the most efficient, modern and flexible BWTS combines initial filtration with enhanced UV treatment in a specially designed reactor. This system has has a large spectrum of species that he is eliminating without being harmful to the environment.The system with is using UV lamps is safe to handle and to be operated by the crew. There are no additives to the process that could harm the vessel or equipment onboard.

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УДК 621
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RESEARCH OF TRIBOLOGICAL PROPERTIES OF COATINGS OF PISTON RINGS OF A MARINE INTERNAL COMBUSTION ENGINE

Octavian Narcis VOLINTIRU, Mihail - Vlad VASILESCU, A. I. Epikhin, T.G. Toriya, M.L. Somko, M.A. Modina

The article is devoted to the analysis of changes in the tribological properties of ship engine piston ring coatings obtained using different coating methods. The analysis of the rate and nature of wear of the coatings of piston