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MEANS OF REDUCING THE IMPACT ON ARCTIC ENVIRONMENT OF AN ICEBREAKER BALLAST SYSTEM

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Abstract: Generally, icebreakers have been built as nuclear-powered Arctic ships, but for reasons related to the protection of the environment, and especially the Arctic environment, this trend has begun to change. A nuclear icebreaker is a type of nuclear-powered motor vessel for use in ice-covered waters. In winter, the ice along the North Sea route varies in thickness from 1.2 to 2.0 meters. The ice in the central parts of the Arctic Ocean has an average thickness of 2.5 meters. Nuclear icebreakers can pass through this ice at speeds of up to 10 knots (19 km/h). In ice-free waters the maximum speed of icebreakers is up to 21 knots (39 km).

Key words: icebreaker, Arctic, ballast, environment, design.

1. INTRODUCTION

Arktika-class icebreakers are used to break ice for the benefit of merchant and other vessels along the North Sea route, which includes the eastern part of the Barents Sea, the Pechora Sea, the Kara Sea, the Laptev Sea and eastern Siberia, Bering Strait. Important ports served by these icebreakers include Dikson, Tiksi and Pevek. Of the six Arktika-class icebreakers built between 1975 and 2007, four are currently in operation.

Two super-nuclear breakers, Vaygach and Taymyr, were built for shallow water and commonly used from the Yenisei River to the Dikson, where they pass through ice, followed by Igarka timber merchant ships and ore and metal merchant ships. from the port of Norilsk Company in Dudinka.

Icebreakers have been used and are still used for a number of scientific expeditions in the Arctic. On August 17, 1977, the Arktika was the first surface ship in the world to reach the North Pole. Since 1989, some have been used for several Arctic cruises.

In total, ten civilian nuclear-powered ships were built in the USSR and Russia. Nine of them are icebreakers, and one is a container ship with a bulb specially designed for ice. All six Arktika-class icebreakers were built at the Baltic Shipyard in St. Petersburg. Vaigach and Taimyr were built at the Helsinki Shipyard in Finland and then brought to Russia for the installation of reactors and turbogenerators.

Russia plans to start building new icebreakers, the 22220 project after 2020. In June 2008, Rosatom head of state Sergei Kiriyenko said: *"It is important not only to use the existing icebreaker fleet, but also to build new ships, and the first new-generation nuclear icebreaker will be built by 2025. It should be an icebreaker capable of moving on rivers and seas"* he said. He went on to say that the St. Petersburg Iceberg Design Office will prepare the icebreaker project by 2019.

According to the BBC, the LK-60 (LK60Y) will be the largest icebreaker ever built. Vladimir Putin said in 2020 that Russia is building at least three new-generation nuclear breakers between 2022 and 2030.

The construction of a nuclear icebreaker takes eight years, the fuel resource lasts about 25 years. According to the Ministry of Transport, Russia needs six new icebreakers in the future.

Figure1 Norwegian icebreaker *Roald Amundsen* built for Arctic tourism (no nuclear propulsion)

Icebreakers generally try to navigate routes with the least ice to make faster progress and make sure they are not caught in too much ice and break them. In the 1970s and 1980s, ground aircraft observed and mapped ice to help choose routes. Over time, most of this work has

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been taken over by satellite surveillance systems, sometimes aided by helicopters carried by ice.

Since 1989, nuclear icebreakers have also been used for tourism purposes and carry passengers to the North Pole. Each participant pays up to $ 25,000 for a three-week cruise.

2. ASRV *LAURENCE M. GOULD* ICEBREAKER

ASRV *Laurence M. Gould* is an icebreaker used most of the time by researchers at the National Science Foundation in the United States. The ship is being operated for research in the Southern Ocean. The ship is named after Laurence McKinley Gould, an American scientist who had explored both the Arctic and Antarctica. He was the second commander of Admiral Richard E. Byrd's first expedition to Antarctica from 1928 to 1930. He helped establish an exploration base at Little America on the Ross Ice Whaling in the Gulf of Whales.

ASRV Laurence M. Gould is operated under the Antarctic Support Agreement (ASC) on a long-term charter from Edison Chouest Offshore (ECO). The ASC shall incorporate the ship with a charter representative to coordinate the planning and scheduling of voyages and expeditions and shall provide on-board specialized technical personnel to support scientific operations. ECO shall provide the master of the ship, the pilot for navigation in ice-covered areas, and the crew prepared for this purpose.

Figure 2: ASRV icebreaker *Laurence M. Gould*

The construction of the ship was completed in 1998, and as main construction features has a length of 115 meters and is classified according to ABS-A1, capable of breaking ice with a thickness of 2 meters at a specific pace with continuous forward movement. ASRV Laurence M. Gould can accommodate 37 scientists on board, as well as crew members in cabins with one or two people. Upon request or need, the vessel acts as a supply vessel and conducts long-term environmental research (LTER), especially in the Drake Passage and the Antarctic Peninsula, the route normally approached being between Punta Arenas, Chile and Palmer Station, Antarctica. It replaced the RV Polar Duke as the main supply ship to the US Palmer research station.

The main technical characteristics of the ASRV Laurence M. Gould are the following:

- Owner: Offshore Service Vessels LLC;
- Builder: North American Shipbuilding, USA;
- Year of construction: 1997;
- Classification: Icebreaker of ice class ABS A1;
- Flag: United States of America;
- Total length: 72.2 m;
- Length between perpendiculars: 64.7 m;
- Construction width: 14.02 m;
- Width with ice reamers: 17.1 m;
- Draft: 5.49 m;
- Construction depth: 7.85 m;
- Weight of the empty ship: 2799 tons;
- Deadweight: 1041 tons;
- Displacement at the loading line: 3841 tons;
- Gross tonnage: 2966 tons.

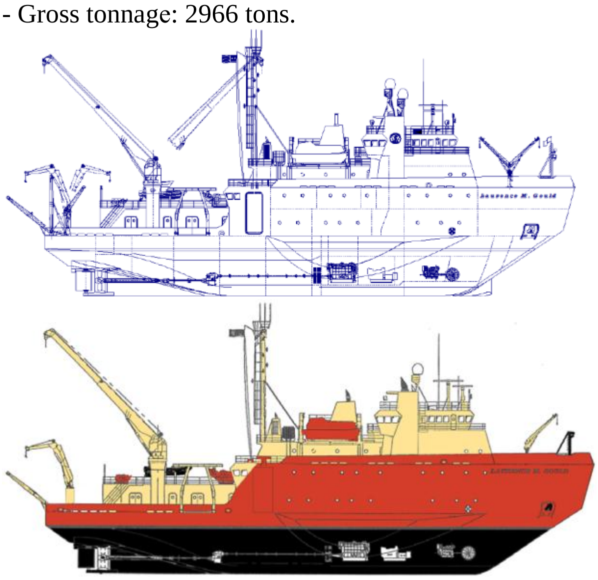

Figure 3: Construction diagram and arrangement of the main installations on board the ship

The ship has a series of spaces, compartments, equipment and installations exclusively intended for research activity, from which can be exemplified:

- Wet Laboratory: 40 m^2;
- Hydro Laboratory: 51 m^2;
- Dry Laboratory: 35.6 m^2;
- Computer Room: 46 m^2;
- Laboratory Aquarium: 27 m^2;
- Environmental Laboratory: 5 m^2;
- Laboratory microscope: 5 m^2;
- Scientific workshop: 38 m^2;
- Baltic Room: 42 m^2.

3. PARTICULARITIES OF SHIP BALLAST SYSTEMS

Ballast systems for general use

For general, passenger, refrigerated, fishing and other cargo ships, a single centralized ballast system is

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used to correct both the flag and the axle. An exception to this centralized system is the ballast tanks of the bow of the oil pumps of the autonomous pump, arranged in one of the bow compartments. On these ships, in the race without payload, the ballast in the cargo tanks is introduced through the Kingston valves, through the free flow, or with the help of the loading pumps and the afferent pipes (which serve for him).

The ballast system of each ship must be serviced by at least one pump, and as a reserve pump others can be used, which have a sufficient flow (fire pumps can only be used if the system is not intended for the storage of liquid fuel).

The piping of the ballast system must be so arranged that the filling and emptying of the various tanks can be carried out independently, both when the ship is on the right keel and when it is inclined. The ballast system must be operated with as little ballast as possible, which will ensure the necessary stability and immersion of the propellers in the empty course of the ship. For general cargo ships the ballast does not exceed 20% of the ship's displacement. It takes 6-8 hours to load the entire amount of ballast, and it usually takes less than 2 hours to fill or empty the larger tank.

Specialized ballast systems

In particular, they are found in icebreakers, container ships, barge carriers, floating docks and submarines.

In the case of icebreaker ships, the problem is that the ballast systems generate oscillations during the ship's stationary oscillations with very large periods, so that, during the stationary ship, the ship is not caught in the ice. In the case of container vessels, barges or Ro-Ros, which carry very large concentrated loads, there is the problem of quickly correcting the inclinations caused by the eccentric arrangement of the weights on board. There are barge carriers at which the loading of barges is done by ballasting the base ship. For the submarine, the ballast system determines the condition of immersion and lifting to the surface.

Ballast systems for list correction

Transversal inclinations may occur during the operation of ships as a result of incorrect loading of goods, uneven fuel consumption or other causes. The transverse inclination worsens the ship's management, the operation of the machines, the mechanisms and the installations, it makes the service difficult. The transverse inclination must also be corrected in the case of damaged vessels.

The ballast system for the correction of the transverse inclination must meet the following conditions:

- not to influence the position of the ship;
- not to worsen the transversal stability;
- to request a minimum quantity of ballast arranged in ballast tanks located in the double bottom or side or even in fuel tanks (mixed tanks).

On icebreakers, the ballast systems must be automated to ensure the oscillation of the ship with a certain period. The ballast should be arranged in compartments located in the middle region of the ship (as sideways as possible) to ensure a lever arm and so on, as high a moment of transverse inclination as possible. In the case of damaged ships, the ballast shall be arranged as low as possible, so as not to further reduce the transverse stability.

The loading of ballast tanks with water from the outside of the ship, the transfer and refuelling of the board can be carried out with the pumps of the installation or with the pumps of the installations of longitudinal ballast, bilge, rescue (emergency) and sometimes with heat. In order to correct the inclinations of the ships, the ballast is embarked by the free flow through the Kingston valves, which simplifies the construction of the installation. For the same purpose, the pipes between the side tanks can be used, through which the water can flow freely from one board to the other.

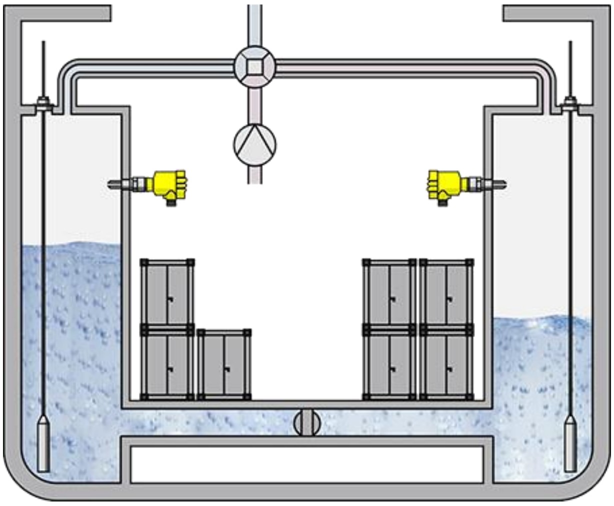

Figure 4: Schematic diagram of a specialized ballast system

Shipbuilders use the stand-alone scheme for ice breakers. In each watertight compartment in which two ballast tanks are located, autonomous pumps are fitted. The use of axial pumps on the double bottom platform ensures a good operation and the possibility of transferring water from one board to another in a period of 1-3 minutes, which is sufficient for the operation of ice breakers.

In order to ensure the vitality of the ships, the ballasts of the ballast installation of the different compartments (built according to the autonomous principle) are in communication with a transfer pipeline provided with a manoeuvring valve.

Ballast systems for axial correction

The system for the correction of the axle list must meet certain requirements imposed by the type of ship, the qualities of navigation and the longitudinal stability.

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If, by flooding a sealed compartment, the ship acquires a dangerous longitudinal deviation from the point of view of longitudinal stability or flooding, the list must be corrected within a maximum of 5-10 minutes. On transport ships with high longitudinal stability, even in the event of damage to the extreme compartments, the ship can be returned to the raft line in 20-60 minutes, if special conditions are not foreseen by the design.

Ballast systems for the correction of the axial list are provided for on ice breakers which usually have during operation an almost constant displacement, as is the ARSV ship *Laurence M. Gould*. On ships carrying bulk cargo, on tanks, on passengers etc. no special ballast installations are provided for the correction of this. For the operation of these systems, it is necessary for the ballast to be disposed of in the ballast or fuel tanks at the ends of the ship. Ballast tanks can be placed at body height anyway, as the centre of gravity of the ballast has little influence on the longitudinal metacentric height.

If the ballast is admitted through a bottom valve, the tank must be placed as low as possible below the waterline in order to have the highest suction pressure and the shortest possible filling time. The installations intended for the correction of the axial list (in case of damage) are executed with group or autonomous control, and in the case of ice breakers and with centralized control (with main piping).

On relatively large vessels, one part of the tanks can be filled through the bottom valves, and the other part (upper tanks) with the help of pumps. In order to ensure the necessary reserve, the piping of the ballast installation for the correction of the axis will be in communication with other water pumps. The construction of the installation allows the filling of the tanks through the bottom valves or with the help of the pump that serves and the emergency systems.

The emptying of the tanks is also carried out with the pump. The control of the level in the tank is done with the help of a float valve, which automatically interrupts the water intake in the tank, when it has reached the set level. A similar vent can be mounted on the suction line to prevent air from entering the piping at the end of emptying the tank and thus defusing the pump. These valves can transmit impulses to the signalling system, which indicate the degree of filling or emptying of the tank, completion of filling or emptying.

4. LAURENCE M. GOULD'S BALLAST SYSTEM. GENERAL DESCRIPTION

Ballast water aboard ARSV *Laurence M. Gould* is loaded into ballast tanks arranged in a graphic representation corresponding to the ship's documentation, and their capacity is detailed below in the table below.

Table 1: Load capacity of ballast tanks aboard ARSV *Laurence M. Gould*

Compartment		**Location**	**capacity**	
		Frame	**At 100% load**	
			m^3	**MT**
No.1 WBT tank	(C)	122 – 130	236,75	242,67
No. 2 WBT bord tank	(P)	112 – 122	37,18	38,11
No. 2 WBT bord tank	(S)	112 – 122	245,36	251,49
No. 2 WBT double bottom tank	(C)	112 – 122	245,36	251,49
No. 3 WBT bord tank	(P)	102 – 112	36,16	37,06
No. 3 WBT bord tank	(S)	102 – 112	36,16	37,06
No. 3 WBT double bottom tank	(P)	102 – 112	201,55	206,59
No. 3 WBT double bottom tank	(S)	102 – 112	201,55	206,59
No. 4 WBT bord tank	(P)	92 – 102	65,11	66,74
No. 4 WBT bord tank	(S)	92 – 102	65,11	66,74
No. 4 WBT double bottom tank	(P)	92 – 102	197,16	202,09
No. 4 WBT double bottom tank	(S)	92 – 102	197,16	202,09
No. 5 WBT bord tank	(P)	82 – 92	94,16	96,51
No. 5 WBT bord tank	(S)	82 – 92	94,16	96,51
No. 5 WBT double bottom tank	(P)	82 – 92	149,35	153,08
No. 5 WBT double bottom tank	(S)	82 – 92	152,56	156,37
No. 6 WBT bord tank	(P)	72 – 82	94,42	96,78
No. 6 WBT bord tank	(S)	72 – 82	94,42	96,78
No. 6 WBT double bottom tank	(P)	73 – 82	118,41	121,37

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No. 6 WBT double bottom tank	(S)	73 – 82	118,41	121,37
No. 7 WBT bord tank	(P)	62 – 72	93,71	96,05
No. 7 WBT bord tank	(S)	62 – 72	93,71	96,05
No. 7 WBT double bottom tank	(P)	62 – 72	148,67	152,39
No. 7 WBT double bottom tank	(S)	62 – 72	151,87	155,66
No. 8 WBT bord tank	(P)	52 – 62	50,53	51,80
No. 8 WBT bord tank	(S)	52 – 62	50,53	51,80
No. 8 WBT double bottom tank	(P)	52 – 62	195,	199,87
No. 8 WBT double bottom tank	(S)	52 – 62	195,00	199,87
No. 9 WBT tank	(P)	13 – 22	162,37	166,43
No. 9 WBT tank	(2)	13 – 22	162,37	166,43
TOTAL			**3984,2**	**408,38**

The water is introduced or removed from the ballast tanks to allow the maintenance of a proper ballast, but also to the ship, as well as to ensure optimum stability, thus the forces to which the ship's body is subjected and limited. Ideally, no more than one ballast tank should be partially filled at any time during the operation of the ballast plant, as long as the free surface of the tanks can generate an effect that can be stable. more tanks to be only partially filled to adjust the ship's GM.

Anti-list tanks, more precisely ballast tanks Nr. 6 of the curbs, make exceptions to this rule, while they are only partially filled to maintain the inclination of the vessel within normal limits when loading and unloading the containers on the vessel. The water is pumped from the anti-tilt tanks, the water being circulated between them, through an anti-tilt pump, to maintain the right position of the ship, although the anti-tilt tanks are filled and finally emptied from the pump ballast.

In ballast systems, centrifugal pumps are used, characterized by a relatively high yield, a safety and a long service life, reduced mass and gauge, simple construction and operation. By placing them pumped to the lower level of the circuit on which they serve, their self-priming is also ensured. Moreover, after stopping the engine, the pumps of this type do not block the connection between the suction and discharge. The aim is to ensure the free circulation of the cooling fluid in the engine (the so-called thermosyphon effect), resulting in the continuation of the cooling process of the engine parts and a uniformization of the temperatures.

In accordance with the functional characteristics of centrifugal pumps, their flow rate varies in direct proportion to speed. If the pump drive is carried out by the engine, then at reduced speeds the flow of pumped water may be insufficient and the engine may overheat. This results in the need to choose a coefficient to increase the flow rate for the pumps driven by the engine. In the case of electric drive of the cooling pump, the flow rate is kept approximately constant. This time, at reduced engine loads, the water flow is exaggerated, with a high energy consumption. For this reason, it is reasonable for the flow rate of the water conveyed by the cooling pump to correspond to the operating speed of the engine.

The electric drive is characterized by a high safety in operation, by the possibility of using the pump in several circuits, as well as by the possibility of rapid transition to operation with the reserve pump. There is also the possibility of a better location of the components of the cooling system in the car compartment. Among the shortcomings of this shareholder system is the dependence of their operation on the supply of electricity, as well as a specific consumption of higher energy.

Mult-stage centrifugal pumps are provided with several rotors fixed on the same shaft. The working fluid is driven in turn by each rotor, its pressure increasing after each stage, so that after the last rotor, at the pump outlet, it is approximately equal to the product of the resulting pressure and the resulting number stages). Centrifugal machines are not generally self-priming. In order to be put into operation, it is necessary to fill the suction pipe with liquid or to evacuate the air from the priming pipe:

- insecure clerk;
- valve operation with suction check valve;
- employee with priming station. In general, the priming station comprises in its structure a volume pump or an ejector;
- coupling to the same shaft on which the rotor of the centrifugal pump of a pump is fixed with the water ring.

The pumps that support the ballast installation aboard the ship ARSV *Laurence M. Gould* are the following:

Ballast pumps

- Manufacturer: Desmi A / S;
- Number of seats: 2;
- Type: Vertical, arranged in line, centrifugal, with self-priming;
- Model: NSL300-415 / E14;
- Capacity: 50 m^3 / h at 10 mth.

Ballast ejector pumps:

- Manufacturer: Ki-Won Industrial Co ;
- Number of seats: 2;

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- Capacity: Training: 700 m^3/h;
Aspirations: 150 m^3/h;
- Training pressure: 3.0 kg/m^2.

Figure 5: DESMI NSL300-415/E14 pumps fitted in the ballast system on board the ARSV *Laurence M. Gould*

Ballast pumps can suck water from the salt water junction dedicated to cooling the main engine in the engine room to ensure ballast water and the operation of the pressure driven ejector. Ballast pumps, during ballasting, discharge water through their ballast lines directly to the board, or through ballast ejectors when ballast tanks are stripped or washed. Although the water level in the anti-tilt system ensures a certain transfer of water, the pumps are ordered separately, the anti-tilt tanks are initially filled or gradually emptied through the ballast pumps. The ballast system is controlled by the central system of the ship or from the wheelhouse at the operator's station, which ensures the control of the pumps, start and stop, sending commands to open to the valves to close automatically. The valves are hydraulically operated. The remote control system of the valves is described in the next section.

5. SYSTEMS USED BY LAURENCE M. GOULD'S TO REDUCE THE ENVIRONMENTAL IMPACT OF ITS BALLAST SYSTEM

The ARSV icebreaker *Laurence M. Gould* is compliant for navigation in unrestricted areas, but also built in accordance with the MARPOL 73/78 Protocol, being an icebreaker with a special ballast system that is transported in the fore peak and other six pairs of winged tanks (the extreme sides of the keel) arranged along almost the entire length of the ship. The fore peak tank can be used frequently as a ballast tank.

The ship is designed with sufficient ballast capacity to meet buoyancy requirements in severe weather conditions, as well as to meet any weather conditions without the need to load additional ballast.

The potential performance of ballast voyages must take into account the seasonal weather conditions that the ship will encounter and therefore there can be no generally valid rule on the condition of ballast tanks in these conditions. The draft read from the markings in the middle of the vessel must not be less than 4.66 m and the trim must not exceed 1.195 m from the stern in these conditions for navigation in ice-covered areas. According to the data in the ship's technical data sheet the ship shall meet the following conditions of draft and stability in relation to the ship's ballast:

- On departure from port:
  - o Average draft: 8.00 meters;
  - o Trim: 1,129 meters at the stern;
- Upon arrival in port:
  - o Average draft: 8.00 meters;
  - o Trim: 0.805 meters at the stern.

The main ballast water tanks on board the ARSV Laurence M. Gould are served by two electrically operated centrifugal pumps and each has a capacity of 50 m3 / h. The ballast pumps are located in the pump chamber and are equipped with a Kingston ballast caisson. The electric drive motors are located on the mezzanine deck, and these pumps have drive shafts that pass through the seals in the pump chamber. The pumps are connected to a discharge overboard by a 600 mm tubular line ending approximately 0.5 m above the deepest ballast line on the starboard side.

Ballast pumps can be connected to the cargo tank system via the manually operated valve, 440 V (shown in Figure 3.5), by inserting a dedicated part for feeding the coil, the manually operated valve, 085V and the check valve 084V. Under normal circumstances, this connection would not be used to ballast cargo tanks intended for use for this purpose only due to severe weather conditions.

The ballast dedicated to the operation of the ship in severe weather conditions will be directed to the cargo tank designated by a main cargo pump, after a basic wash of it. The main ballast lines have a diameter of 500 mm and each ballast tank has a suction line of 350 mm, including the fore peak tank.

Ballast water contains a variety of organisms, including bacteria and viruses, adult forms and larvae of many marine plants and animals, but especially those from coastal areas. While the vast majority of these organisms will not survive to the point where ballast is unloaded, some may survive and thrive in their new environment. These so-called "non-native" (or invasive) species, if successfully established in a certain area, can have a serious ecological, economic and public health impact on the host environment.

The transfer of invasive marine species to new environments through ballast water has been identified as one of the major threats to the world's oceans. In response, the United Nations Conference on Environment and Development (UNCED), held in Rio

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de Janeiro in 1992, in its Agenda, item no. 21, called on the International Maritime Organization (IMO) and other international bodies to take steps to address the issue and find solutions to minimize the impact of this phenomenon.

At the right time, the IMO was already looking for a solution for more than 10 years. In 1991, it published a regulation called the Guidelines for the Prevention of the Introduction of Unwanted Organisms and Pathogens from Ships' Ballast Waters and Sediment Discharges. This regulation was updated in 1993. Further, in 1997, the IMO published Guidelines for the control and management of ship's ballast water to minimize the transfer of harmful aquatic organisms and pathogens, also officially known as Resolution A. .868 (20).

In February 2004, the IMO adopted the International Convention on the Control and Management of Ballast Water and Sediments on Board Ships (Ballast Water Management Convention or BWM Convention) to regulate the level of ballast water discharges and to reduce the risk of introducing non-native species from ship ballast. To complement the BWM Convention, the IMO has adopted more than 15 sets of guidelines and regulations, as well as other documents contained in the resolutions and circulars of the Committee on the Protection of the Marine Environment (MPEC).

The BWM Convention imposes a difficult standard in the ballast water discharge process. In response to this regulation, a number of technologies have been developed and marketed by various suppliers. Many originate in terrestrial applications for municipal and industrial water and effluent treatment, being adapted to meet the requirements of the BWM Convention and shipboard operations. These systems must be tested and approved in accordance with the relevant IMO guidelines.

Thus, in order to achieve the standards imposed by the rules on the management of ballast water, shipowners and seamen on board must take into account:

1. Ballast water and sediment management in accordance with the Ballast Water Management Plan - Ensure that all ballast and sediment water discharges are managed in accordance with the requirements of the BWM Convention and in accordance with the procedures in the Management Plan of ballast water approved and existing on board the ship. It shall ensure that records of ballast operations and sediment management are properly recorded in the Ballast Water Logbook.

2. Update of the Ballast Water Management Plan and the Ballast Water Logbook - Periodic reviews of the Ballast Water Management Plan will be carried out and updated as necessary.

3. Ensure that the necessary checks are carried out within the permitted deadlines - The necessary annual, interim and renewal checks shall be organized in a timely manner and shall ensure that they are carried out within the permitted deadlines.

4. Carrying out maintenance operations on the equipment in accordance with the manufacturer's instructions - The ballast water treatment system must be used and maintained properly, in strict accordance with the manufacturer's instructions. The procedures in the Approved Ballast Water Management Plan will reflect this requirement.

5. Constant monitoring of treatment system performance - System performance should be monitored using installed monitoring equipment or using dedicated sensors. The parameters that this system monitors will vary depending on the type of system you are installing. These include: wash rate / frequency; dosing rate of the active substance; neutralizer dosing rate; energy consumption; TRO (total residual oxidant used); and pH (acidity / alkalinity). The assistance and periodic verification of the system by the manufacturer and the periodic performance of biological efficacy checks will contribute to ensuring the operation of the system as designed and certified.

6. Ballast water and sediment management in accordance with USCG requirements, if applicable - Ensure that all ballast and sediment water discharges are managed in accordance with USCG requirements and in accordance with the procedures in the USCG Water Management Plan. ballast approved and existing on board the ship. It shall ensure that records of ballast operations and sediment management are properly recorded in the Ballast Water Logbook.

An EcoBallast H2233 treatment system is installed to optimize the operation of the ship in the Arctic, as well as the operation of the ballast system on board the ARSV Laurence M. Gould. In principle, the EcoBallast system consists of the filter unit, the UV reactor, the cleaning unit and its control unit. The system is controlled via the PLC installed in the control panel.

The filtration unit can significantly reduce the amount of sediment that comes from ballast water and can also remove a large part of marine organisms (which are larger than 50 microns in size). The filter works fully automatically to influence the filtration process, and its wash water is returned to the seawater on site. The filter unit only works during the ballasting process. During the ballasting process the unit is bypassed.

The UV reactor, which is specially designed for the EcoBallast type system, is intended to reduce the space required within the installation and to maximize its efficiency by using high intensity, but also ultraviolet lamps at medium pressures. This means that the ballast water is treated again to destroy any type of organism during the ballasting process that could have developed inside the ballast water tank during the voyage.

The control system controls the entire ballasting process, all event logs and generates alarms whenever something happens. The ballast card in the system control panel adjusts the power of the UN lamp. The CIP (cleaning in-place) unit is an automatic service device that cleans the quartz bushes that cover the ultraviolet lamps after performing any ballasting-ballasting

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operation. The operation is performed to avoid any type of deposition that may come from seawater, which could, in fact, reduce the efficient treatment of the ultraviolet reactor.

Ballasting - Seawater is sucked in through the suction box. The water then passes through the filtration unit, which reduces the amount of sediment in it, but also removes some of the marine organisms and particles larger than 50 microns. The water finally reaches the UV reactor which generates UV radiation which kills the organisms and breaks them down. The filter unit is then washed back to keep the filter clean. The return wash water is to be poured directly into the sea.

The ballasting process begins with a preliminary phase called initialization which can begin when the power supply level is reached through the ship's onboard power management system (ship's PMS).

Ballast water reaches the filling line, the UV reactor and the filter unit in Sea-to-Sea mode. The filling flow must be as low as possible to prevent hydraulic shock from occurring in the network and in the filling chambers directly from the initialization step. Hydraulic shock can damage the filter element and the quartz bush to protect the lamp from ultraviolet light. Therefore, the intermediate valve (BT-05) must be gradually opened up to 20% in order to prevent the formation of the pressure shock and at the same time to maintain a minimum flow. It is then necessary to open the valve completely to allow maximum flow and to operate all ultraviolet lamps automatically.

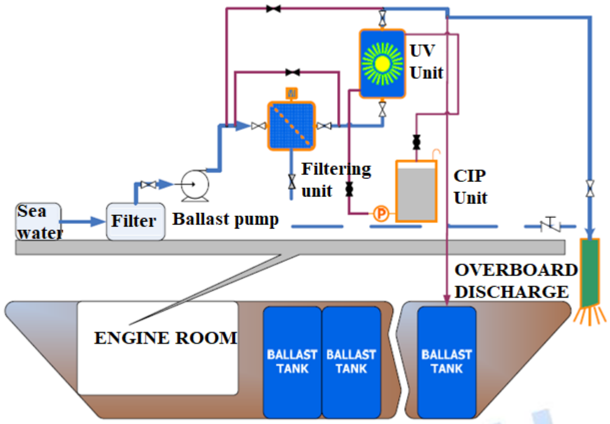

Figure 6: The water circuit in the ballasting process of the *EcoBallast* system

The flow process is monitored by the flow meter installed on the unit to ensure that the "maximum flow" is not exceeded. If the flow value exceeds the nominal value or if it is lower than the nominal flow value, an alarm will sound and the whole system will be switched off automatically.

Upon completion of the above-mentioned starting procedures, the actual ballasting process begins, and the water is directed to the ballast water tanks to fill them with pure, treated ballast water.

De-ballasting – de-ballasting is a procedure similar to ballasting except that a bypass is made on the installation filter. Ballast water is only treated again by the UV reactor to destroy any type of organism that could have grown back inside the tanks during the voyage. The figure below shows the water circuit in the ballast plant during the ballasting process.

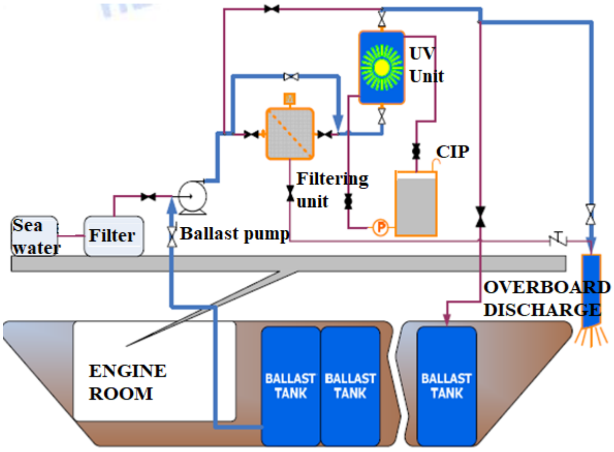

Figure 7: The water circuit in the de-ballasting process of the *EcoBallast* system

System cleaning process - After each ballast procedure, a cleaning cycle takes place in the UV reactors. This cleaning can be performed automatically or manually after each ballast procedure. This cleaning fluid is reused between cleaning operations.

Emergency operation bypass - The emergency bypass operation is performed for ballasting and ballasting procedures without affecting the operation of the conventional ballast water pump.

Preparations and preconditions - Before starting the EcoBallast ballast installation, follow the preparation steps below:

- Ensure that the UV reactor and filter unit are filled with water;
- The main power supply must be connected to the system;
- All valves outside the ballast system must be open or closed in the appropriate position for ballasting / ballasting as shown in the tables below;
- The valves in the EcoBallast system must be in the following positions, depending on the selected operating mode.

6. CONCLUSIONS

If 10 years ago ballast water was apparently not a danger to the environment, today regulators have noticed the negative potential of the ballast installation on the environment through which the ship passes. The potential performance of ballast voyages must take into account the seasonal weather conditions that the ship will encounter and therefore there can be no generally valid rule on the condition of ballast tanks in these conditions. The draft read from the markings in the middle of the studied vessel shall not be less than 4.66 m and the trim shall not exceed 1.195 m from the stern in these conditions of navigation in ice-covered areas, for the ASRV Laurence M vessel. Gould. The discharge valves of the ballast pump are of proportional type, ie they can be opened between 0 and 100%. The main suction valves on the ballast tanks and the isolation valves of the suction line are all of the simplistic type and can only be operated in open / closed positions. The main danger to the environment is invasive species that can be transported by ballast water. The main legislative norm is the BWM Convention, which entered into force 12 months after its ratification by 30 states, representing 35% of the world's shipping tonnage. This provision covers 7 key points regarding the ballasting and unloading of ships. An EcoBallast H2233 treatment system is installed to optimize the operation of the ship in the Arctic, as well as the operation of the ballast system on board the ARSV Laurence M. Gould. In principle, the EcoBallast system consists of the filter unit, the UV reactor, the cleaning unit and its control unit. The system is controlled via the PLC installed in the control panel. Thus, the last part of the study describes the principles and stages of operation of the ballast water treatment plant on board the reference icebreaker.

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