

# Sustainable Ship Management

Gorana Jelic Mrcelic and Merica Sliskovic

**Abstract**—Environmental responsibility includes improvement of environmental performance in order to reduce environmental impact. This paper gives a short review of some important environmental objectives, targets and actions that modern shipping company should follow.

**Keywords**—Environment, MARPOL, ships, pollutants.

## I. INTRODUCTION

**E**FFECTIVE sustainable ship management means that resources give the best return according to the long-term operational needs. It includes the creation of a safe, healthy and injury-free workplace. Accidents can be prevented by raising the awareness among employees, especially necessity for taking responsibility for the environment. Some of indicators can be monitored by monthly reporting, yearly evaluation and yearly planning of objectives, targets and actions [1]. International and national legislation, international standards and guidelines that should form the basis of the company work.

## II. ISO 14001 STANDARD

ISO 14001 Standard certification is a voluntary international standard for environmental management systems which goes further than applicable rules, regulations and the ISM Code. It gives guidance and systemises the environmental work. The first step is to identify all environmental impacts of the company. It has to be regularly performed to find any new or forgotten environmental impacts. The next step is to find the significant aspects and decide objectives and targets. Aspects can be weighted based on various criteria: possible damage, use of renewable resources, effects on the public image, breach of rules and regulation, technical feasibility. It is vital that the objects are both economically and technically feasible in order to realise and to perform the necessary action. It is important to decide the targets in order to reduce impact on the environment and continuously improve the environmental impacts by reducing consumption, use less polluting substances, etc. In order to have evidence for both impact and improvements it is necessary to find measurable points for all the objectives and regularly monitor them to ensure compliance with the environmental program.

Gorana Jelic Mrcelic is with the University of Split, Maritime Faculty, Split, 21000 Croatia (phone: +38521380762; fax: +38521380759; e-mail: gjelic@pfst.hr).

Merica Sliskovic is with the University of Split, Maritime Faculty, Split, 21000 Croatia (phone: +38521380762; fax: +38521380759; e-mail: merica@pfst.hr).

## III. ENVIRONMENTAL OBJECTIVES, TARGETS AND ACTIONS

According to [1], it is always relevant to raise environmental awareness and to reduce energy and paper consumption. Here are some examples of environmental objectives, targets and actions:

- 1) Ballast Water. Avoid spreading of non-native species via ballast water - use of ballast management plan and installation of Ballast Water Treatment Systems - implementation of ballast treatment system according to the vessel installation plan.
- 2) Consumption of bunker and emission of exhaust gasses. Reduce consumption of non renewable resources and emission of exhaust gases to the atmosphere - reduce CO<sub>2</sub>, SO<sub>x</sub>, NO<sub>x</sub> and particulate matter emissions - implementation of various measures according to Environmental Plan (EP).
- 3) Use of lubricating oil. Reduce emissions related to the cylinder oil consumption and reduce the impact of pollution in the case of oil spill from hydraulic system and oil to sea interface systems - implementation of various measures according to Environmental Plan (EP).
- 4) Discharge of Bilge water. Reduce impact of oil and chemical residues from bilge water in the oceans - implementation of various measures according to Environmental Plan (EP): reduce generated bilge, monitoring generated bilge water, evaluation of bilge treatment systems in use and looking for improved technologies.
- 5) Use of cleaning chemicals. Reduce impact to the ecosystem from cleaning chemicals - reduce use on cleaning chemicals used onboard - implementation of various measures according to Environmental Plan (EP).
- 6) Refrigerant. Reduce impact on the ozone layer and to the global warming effect from emission of released refrigerant gases - reduce consumption/emission of refrigerant used onboard - implementation of various measures according to Environmental Plan (EP).
- 7) Consumption of fluorescent tubes. Reduce impact from released mercury to the ecosystem - reduce consumption of the mercury from fluorescent tubes - implementation of various measures according to Environmental Plan (EP).
- 8) Raise environmental awareness. Improve environmental awareness: according to [1] all onboard personnel to undergo environmental training and annual Environmental Day onboard - implementation of various measures according to Environmental Plan (EP).

#### IV. ENVIRONMENTAL PLAN HOTSPOTS

The most important sources of pollution from the ships are given in this section. The International Convention for the Prevention of Pollution from Ships (MARPOL) is the main international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes. The MARPOL Convention was adopted on 2 November 1973 at IMO. The Protocol of 1978 was adopted in response to a spate of tanker accidents in 1976-1977. As the 1973 MARPOL Convention had not yet entered into force, the 1978 MARPOL Protocol absorbed the parent Convention. The combined instrument entered into force on 2 October 1983. In 1997, a Protocol was adopted to amend the Convention and a new Annex VI was added which entered into force on 19 May 2005. MARPOL has been updated by amendments through the years. The Convention includes regulations aimed at preventing and minimizing pollution from ships - both accidental pollution and that from routine operations - and currently includes six technical Annexes. Special Areas with strict controls on operational discharges are included in most Annexes. 136 countries or 98% of world shipping tonnage are parties to the Convention [4].

##### A. Oils

The most common systems onboard that has a potential for spilling oils are [1]: bunker operation, bilge water, oil to sea interfaces (stern tube oil, bow thruster oil, rudder and hydraulic operated valves within ballast tanks), oil from cargo holds coming from leakages on hydraulic cylinders and winches, life boat diesel and oil. Bilge water contains a mixture of: heavy fuel oil, diesel oil, fresh water, stern tube oil, hydraulic oil, light detergents, heavy duty detergents, cip-liquid, cooling water/foam liquid, some heavy emulsifier, boiler water (high pH value), salt water, outer special oil, soot water (low pH value), parts of metals, black water chemicals, fibres, colony of bacteria and grey waters with different types of chemicals. Annex I. of the MARPOL Convention [2] describes details of the discharge criteria and requirements for the prevention of pollution by oil and oily substances. It contains seven chapters and 39 regulations that serve as guidelines, information and references for creating instructions, contingency plans and procedures for shipboard application. Annex I. Regulation 15 of the MARPOL Convention [2] gives the requirements for bilge water discharging.—Marine companies can perform some modifications and routines to improve the handling of bilge water from the vessels in order to: increase knowledge for the operators, minimise generation of water and oil, pre-treat and separate oil and water, reduce mix of water and oil, control that non violation discharging occurs, minimise sludge generation, separate water from the sludge prior to incineration, extract usable bunker from the sludge that can be reused, and to provide intensive environmental inspections (once a year).

##### B. Ballast Water

The International Convention for the Control and Management of Ships Ballast Water and Sediments [3] was completed and adopted in 2004, and now is available for ratification. It is divided into articles and regulations including an annex which describes the technical standards and requirements: Regulation D-1 Ballast water exchange standard and Regulation D-2 Ballast water performance standard, Regulation B-3 Ballast water management for ships.—Until the Convention enter into force it is voluntary for the shipping companies to implement the use of a ballast water management plan onboard their vessels. It should be specific to each ship and should at least:

- 1) provide a detailed description of the actions to be taken to implement ballast water management requirements and supplemental ballast water management practices;
- 2) detail the procedures for the disposal of sediments at the sea and to shore;
- 3) include the procedures for co-ordinating shipboard ballast water management plan that involves discharges to the sea with the coastal state authorities;
- 4) designate the officer on board in charge of ensuring that the plan is properly implemented;
- 5) contain the reporting requirements for ships.

The plan should be written in the language of the ship. A translation into English, French or Spanish shall be included.

##### C. Sewage

According to MARPOL Annex IV Regulation 1, sewage, or black water, is defined as: drainage and other wastes from any form of toilets, urinals and WC scuppers; drainage from medical premises via wash basin, wash tubs and scuppers located in such premises; drainage from spaces containing living animals; other waste waters when mixed with the drainages defined before. Grey water is meant to include drainage from dishwasher, shower, laundry, bath, washbasin drains, swimming pools and spas. Grey water is not considered to be sewage and it is not covered by the Regulations nor MARPOL as long as it does not contain a pollutant prescribed in the regulations or MARPOL Annex II. MARPOL Annex IV contains a set of regulations regarding the discharge of sewage into the sea, ships equipment and systems for the control of sewage discharge. The discharge of sewage into the sea is prohibited, except when the ship:

- 1) Has an approved treatment plant – the discharge shall not produce any visible floating solids nor cause discoloration of the water, or
- 2) Discharging comminuted and disinfected sewage using an approved system at a distance of more than three nautical miles from the nearest land, or
- 3) Discharging sewage which is not comminuted or disinfected (raw sewage) en route (at speed more than 4 knots) and at a distance of more than 12 nautical miles from the nearest land.

In the case of an emergency situation it is possible to discharge sewage to ensure the safekeeping of the crew, vessel or cargo.

#### *D. Garbage*

According to Annex V of the MARPOL, garbage includes all kinds of operational and food waste generated during the normal operation of the ship. Typical garbage generated onboard includes: packaging materials, paper, plastic, food waste, soft drinks cans, food tins and cans, bottles, paint cans and oil drums, batteries, steel and steel products old spare parts. All vessels should have specific garbage management plan in which responsibility, equipment, position of containers, etc., should be described. The garbage management plan should provide written procedures for collecting, storing, processing and disposing of ship-generated garbage, including the use of the equipment onboard. It should also designate the person in charge of carrying out the plan. The best garbage handling policy is: no garbage into the sea – no garbage other than food waste is to be discharged into the sea. All the garbage has to be properly disposed off by either incinerator on board or be delivered to shore reception facilities, segregated and marked according to the plan. The vessel onboard has to be segregated according to categories: domestic waste (food waste, plastic, glass, aluminium cans, paper, wood, metal and ash from incinerator) and hazardous waste (used fluorescent tubes, used batteries, paint residues, chemical residues. Food wastes and associated garbage which are returned to port may carry disease or pests and have to be kept separate from other types of garbage. All types of garbage should be in separate, clearly marked containers to avoid incorrect disposal and treatment on land. Garbage containers must be lashed and be of fire proof type and have proper marked covers. All crew are responsible to follow the no discharge policy and routines for garbage handling onboard. All crew have to participate in the collection and segregation of garbage according the plan.

#### *E. Air Pollutants*

The emission of oxides of nitrogen, oxides of sulphur, particular matter, ozone depleting substances and volatile compounds are Annex VI of the MARPOL. Emission of carbon dioxide is not covered by Annex VI of the MARPOL. Air emission generators on board can be divided into:

- 1) group related to combustion, combustion products, fuel oil quality, maintenance and spare parts supply – main engine, auxiliary engine, auxiliary boiler and incinerator that depends on proper garbage segregation;
- 2) group related to equipment maintenance and leaks – refrigerant plant (CFC/HCFC) and tanker ships (VOC).

Annex VI of the MARPOL require that every ship of 400 gross tonnes and above have an International Air Pollution Prevention Certificate (IAPPC) that require a periodic survey every five years. It will have an effect on oxides of nitrogen, oxides of sulphur, particular matter, and ozone depleting substances.-MARPOL Annex VI regulation 14 regulator

sulphur oxides and particulate matter. The sulphur content of any fuel oil used onboard ships should not exceed the following concentrations: 4.5% m/m prior to 1 January 2012; 3.5% m/m after 1 January 2012; 0.5% m/m after 1 January 2020. The worldwide average sulphur content of residual fuel oil supplied for use on board ships shall be monitored according the IMO guidelines. While ships are operating within Emission Control Areas (the Baltic Sea, the North Sea, any other sea area, including port areas, designated by IMO in accordance with criteria and procedures set forth in appendix III to this Annex), the sulphur content of fuel used on board ships should not exceed the following limitations: 1.5% m/m prior to 1 July 2010; 1.0% m/m after July 2010; 0.1% m/m after 1 January 2015. Those ships using separate fuel oils and entering/leaving an Emission Control Area should carry a written procedure showing how the fuel oil change-over is to be done, allowing sufficient time for the fuel oil service system to be fully flushed of all fuel oils exceeding the applicable sulphur content. The volume of low sulphur fuel oils in each tank as well as the date, time, and position of the ship when any fuel-oil-change operation is completed prior to entry into an ECA or commenced after exit from such an area, should be recorded in such log book as prescribed by the Administration.-Regulation 13 of Annex Vi concerns nitrogen oxides emission from diesel engines and should apply to each diesel engine with a power output of more than 130 kW which is installed on a ship constructed on or after 1 January 2000; and each diesel engine with a power output of more than 130 kW which undergoes a major conversion on or after 1 January 2000. This regulation does not apply to: emergency diesel engines, engines installed in life boats or for any equipment intended to be used solely in case of emergency. According to Annex VI operation of applicable diesel engines is prohibited when the emission of nitrogen oxides from the engine was within the following limits:

- 1) **Tier I** - for ships constructed between 1 January 2000 and 1 January 2011: 17 g/kWh when n is less than 130 rpm;  $45 * n^{-0.2}$  g/kWh when n is 130 or more but less than 2000 rpm; 9.8 g/kWh when n is 2000 rpm or more but less than 2000 rpm, where n= rated engine speed and the emission of nitrogen oxides are calculated as total weighted emission of NO<sub>2</sub>.
- 2) **Tier II** - for ships constructed between 1 January 2011 and 1 January 2016: 14.4 g/kWh when n is less than 130 rpm;  $44 * n^{-0.23}$  g/kWh when n is 130 or more but less than 2000 rpm; 7.7 g/kWh when n is 2000 rpm or more but less than 2000 rpm, where n= rated engine speed and the emission of nitrogen oxides are calculated as total weighted emission of NO<sub>2</sub>.
- 3) **Tier III** - for ships constructed after 1 January 2016 when operating within ECA: 3.4 g/kWh when n is less than 130 rpm;  $9 * n^{-0.2}$  g/kWh when n is 130 or more but less than 2000 rpm; 2 g/kWh when n is 2000 rpm or more but less than 2000 rpm, where n= rated engine speed and the emission of nitrogen oxides are calculated as total weighted emission of NO<sub>2</sub>.

Annex VI prohibits deliberate emissions of ozone depleting substances, which includes halons and chlorofluorocarbons. New installations containing ozone-depleting substances are prohibited on all ships, but new installations containing hydrochlorofluorocarbons are permitted until 1 January 2020. The requirements of the IMO Protocol are in accordance with Montreal protocol.

Following increased regulatory vigilance of maritime pollution MARPOL Training Institute Inc. began providing crew training before and following US Department of Justice violation settlements. The training is computer-based training that could be offered repeatedly [5].

#### V. CONCLUSION

Effective sustainable ship management means that resources give the best return according to the long-term operational needs. All employees should always have the commercial operation on the mind, but also safety and environmental footprint. The priority should always be the safety of the people, environment and commercial operations at the lowest possible cost, in that order.

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