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PREVENTION OF POLLUTING RIVERS AND LAKES FROM SHIPS

ABSTRACT

Traffic on rivers and lakes in Europe has been very well developed. The reason for this is the transport cost, relative speed and good connectivity of major European cities by rivers and canals. In Croatia, this transport mode is lagging behind the rest of Europe. Croatia is located at an interesting section of the river transversal, but due to several reasons, river navigation in Croatia has not been developed to any major extent. As operating river ships the most frequent types are: towboats, pushboats and self-propelled ships. The installed diesel engines, propulsion and auxiliary engines run at high power. Proportional to the increase in the power of installed engines is also the increase in the volume of waste produced by the engines. Also, the older the engine, the greater volume of waste it produces. Ships may also cause pollution by wastewaters and garbage. This pollution threat grows with the greater number of people on board and the age of the ship. In order to minimize these possibilities of pollution, it is necessary to control all the time the proper functioning of the ships, train the staff and construct reception facilities on land.

KEY WORDS

oils, wastewaters, garbage, tanks

1. INTRODUCTION

During normal service under the usual conditions of ship operation with all the engines on board working properly, the vessel-source pollution is caused only by exhaust gases from diesel engines. With the engines functioning in perfect order, the pollution caused by exhaust gases can be reduced to a negligibly small value. In practice, during service, the engines are not in perfect condition, and more dangerous pollution occurs, and this will be described in the paper. According to the contaminations mentioned further in the text, the environmental pollution caused by exhaust gases is fairly low.

The ship-owners themselves are those who can contribute most to the reduction of the threat of pollution by keeping their ships in best order and by handling cargo and oils properly. However, considering from their aspect, greater care for the environment leads inevitably also to the increase in costs, so that one cannot rely only on the ship-owners and their ecological awareness. Next on the list of those who should take care of the environment are the classification institutions (further in the text "Register") with regulations and ship inspections and in dry docks that take care of protecting the environment, people and assets. The Register has no possibility of repressive actions against unconscientious ship operators, so that the government also has to play its role in promoting environmental concerns. Through its representatives: port authorities and police, it makes sure that the ship crew operate in compliance with the law provisions of the state of the respective waters, and with the regulations of the Register of their authority.

This method of supervising ships and ship operators is carried out in all the countries, with possible minor deviations. The system is good, and it only requires people to respect it and to comply with it in their operations.

The ships navigating on the rivers and lakes may have different sources of propulsion. Depending on their age, purpose or desires of the ship-owner, the following may be used: propulsion by diesel engine, steam engine, electrical propulsion motor, nuclear power and sails.

Besides, the ships that navigate rivers and lakes have also different deployments: for the carriage of general cargo, special cargo, for the transport of flammable and explosive cargo or for the passenger ships.

Also, different types of vessels navigate the rivers and lakes: tow-boats, push-boats, self-propelled ships, floating plants, ferries, tankers, passenger ships and

others that are not of special interest for the problems dealt with in this text.

Depending on the type of vessel, type of propulsion and the deployment of the vessel, every vessel represent potentially not an equally dangerous polluter. The ships are divided according to several parameters that are significant considering pollution: passenger, cargo with the lowest power of 110 kW (every Register can have its own rules).

When a new ship is constructed, there is a fairly clear procedure of the construction method and of undertaking measures in order to prevent pollution. Every ship has to be constructed under the supervision of a certain Register, chosen by the ship-owner himself, if the state under which flag the ship navigates recognizes it. In cooperation with the Register, the ship-owner selects the designer, who has to be authorized by the respective Register. The designer designs the ship, complying with the rules of the Register on the construction of new ships. After the design has been completed, the documentation has to be approved by the Register. After the approval of documentation and after the correction of possible complaints, the ship starts to be constructed, again under the supervision of the Register. All the procedures and construction phases are agreed between the shipbuilder, Register, and supervisor nominated by the ship-owner, who should protect the interests of the investors, i. e. ship-owner. After the ship has been constructed, it gets clearance for trial navigation, also under the supervision of the Register. If everything is in order, the ship receives the navigation certificate for the period of one year. Every year, the ship is inspected according to pre-determined rules and if the representative of the Register does not have any major complaints, the worthiness of the ship is prolonged for another year. At least once in five years i. e. according to the rule of the Register, every ship should be taken to the dry dock and then inspected in detail, also from the outside. Special attention should be paid to those places on the hull which house the fuel tanks on the inner side.

2. TYPES OF POLLUTION

The types of pollution include pollution by oil, by wastewater and by garbage.

2.1. OIL POLLUTION

Oil on a ship, within this context, indicates: fuel, lubricating oil, hydraulic oil, and sludge. Most ships operate on diesel engines. For its operation, the diesel engine requires: fuel, lubricating oil, cylinder oil and possibly hydraulic oil. All these are substances that are very visible in case of spillage into the river and due to the thin film they cover wide surfaces. Apart from propulsion, the diesel engine is also used as the auxiliary engine to generate electricity. It may be also used for the operation of the anchor windlass. Apart from the diesel engine the ship can be also equipped with a boiler for heating the premises, which uses diesel oil for combustion. Various gears bath in the lubricating oil. The risk of pollution by all these equipment and all the types of oils is present during: loading on the ship, during service, and possible leakage and transport of unusable substances from ship to land.

Oils can be transported onto a ship by pipelines or in special tanks (barrels). If oils are delivered through pipes, these have to be specially tested for such media and the adequate pressure during transport. The couplings on the ships have to be standardized and approved by the Register. Around the very coupling point on the ship a small basin is made of sheets so that in case of oil leakage on the coupling the oil does not leak onto the deck and later into the river. During loading a crew member has to be constantly present supervising the filling and if necessary stopping the oil transport onto the ship. There must also be an available fire extinguisher and a bag of sawdust. Sawdust is a good oil absorber. When oil is loaded by barrels the requirements are less strict, considering there is less danger of pollution.

Every diesel engine may be a cause for oil leakage. When running, the engine is exposed to vibrations and high mechanical and thermal loads. The possibilities of leakage increase, especially at connecting points of the fuel system, oil filter and connecting points of other oils, if there are any on the engine. All the spilt oil leaks from the engine downwards to the garboard or into the engine-room bilge. The engine-room bilge is also the bottom of the ship. Bilge can accept a certain amount of the spilt fluid, but when this amount is exceeded it needs to be stored into a tank planned specially for this fluid. It usually happens that the cooling water leaks into the bilge along with the oil. Mixed with the oil it forms an emulsion which spills easily and often, based on the system of connected vessels over the whole engine-room. In order to keep the bilge more or less dry, the bilge water needs to be transferred to some other place. A special tank needs to be planned for storing the bilge water and its volume depends on the power of the engine and the area of navigation (in river shipping, in Europe, there are three areas of navigation, depending on the navigation conditions that are usually measured by the height of the waves; designated as the navigation area one, two, or three). The tank may be installed or not installed, depending on the Rule of Register requirements. Bigger engines require usually a tank welded to the ship construction. The tank should be fitted with some kind of signalisation so that the level of the fluid in the tank

can be read from the outside. On the more advanced ships this includes both sound and light alarm.

The second part of the system for draining the bilge water is a pipeline system with pumps. The pump capacity has to be sufficient to pump out the whole bilge within a certain period of time (defined by the Register). The material of which the pipes are made and the type of pump have to be approved by the Register. On the points where the leakage from the system is possible, metal pipes need to be installed in order to gather the spilt fluid. This system can also have a pipeline leading to the deck for direct discharge of the bilge outside the ship. The coupling on the deck is also internationally standardized and approved by the Register. Most frequently the bilge is pumped out into the bilge tank, and when convenient from the tank to the on-shore facilities for disposal of bilge water.

The third part of this system is the bilge separator for treating bilge water. This device is installed on the ship at the request of the Register. It may consist of two devices: a separation device and a filtering device.

Systems for separating and filtering oil from the oiled water have to be designed in such a way that they exclude the possibility of draining water with the oil content greater than the stipulated quantity and their design has to be approved by the Register. The system consists of separating and filtering equipment and the alarm. The alarm is used for signalisation in case the oil content in water exceeds the stipulated value. The system for oil separation from the bilge water operates by combining high rotation speed of the oil separator rotor and the difference in the specific weight of oil and water, water is separated at a greater distance from the rotation axis and oil remains closer to this axis. Pure water is then drained outside the ship and oil is transferred to a special sludge tank. The devices have to operate reliably with concentration of oil in the water of 15 ppm and at any ship heeling defined by the Register.

Figure 1 – Pollution by oil

Every ship carrying any oil must have an Oil Record Book – Part I and Part II. This book contains the register about any loading and unloading of all oils on the ship. The Oil Record Book is issued by the Register and controlled by the port authorities and harbour master.

In order to eliminate or at least reduce to a minimum the pollution by waste oils from the ships, it is necessary to prevent the shippers to discharge the waste oils into the river without control. The ships should have waste oil sludge tanks and filtering devices. In case there are no filtering devices, strict register should be kept about the volumes of sludge disposed on the shore. The drainage of bilge should be allowed only in extreme emergency and this should be strictly controlled and recorded.

2.2. POLLUTION BY WASTEWATER

Ships carrying passengers release certain amounts of sewage. The wastewater may be from the galley or from the hotel facilities. On ships these are distinguished by names: grey and black water. Black water is usually sewage from the toilets and hospital and the rest is designated as grey water.

Ships are primarily distinguished by the fact whether they have a tank for collecting sewage. Those that have no such tanks always discharge water out from the ship, whereas the others can collect the water.

Few of the older ships have tanks for collecting sewage, and even fewer have the sewage treatment equipment. The designers thought in the past that the rivers could carry and process anything, and there were not so many ships as today and so they did not represent such a global problem. For the sake of comparison, older sea ships have a device for collecting sewage. The main reason is that any port would sooner or later become too polluted by sewage from the ships which stayed there, since there is little movement of the sea in the port. The filled tanks would be emptied at open sea. The majority of shippers even today, almost always, discharge all sewage directly into the river. The pollution by ship source sewage is relatively low compared to all other types of pollution, but the ships can also create a local pollution problem e. g. in a certain river backwater or in the port with standing water.

Another possibility is to collect sewage in the appropriate tanks. The sewage tanks are planned depending on the number of people on board and the type of ship (whether it is a passenger ship or not). The sewage tank equipment, depending on the type of ship, can be the water level indicator with high-level light and alarms. For the comfort of stay on the ship the sewage tank vents must not pass near to the pre-

mises where people stay longer. The collecting tanks have to be made of steel and the interior protected against the acid action of the sewage. The tanks may have the washing connection as well as the device for mixing (splashing) of waters in the tank. There are, theoretically, three methods of treating the collected sewage: collecting sewage in the port and discharge during navigation or collecting it always and then discharging into the river, or collecting wastewater always and then in every port discharging it at the reception facilities. The simplest and most frequent method is the first one. This procedure is better than having no tank at all, and it prevents local pollution. The second method of treating sewage is used by newer and mainly passenger ships. A great number of people and great comfort of staying on board mean also big amounts of sewage. To discharge untreated water outside the ship would represent significant pollution especially where there is heavy traffic of such ships. Sea ships of later construction have to have sewage treatment devices for sewage. The devices for sewage processing are also constructed under supervision of the Register. They have to have throughput capacity in compliance with the calculated demand of water on the ship. The level of filtered water purity has to be within the stipulated limits. The devices are often equipped with electronic alarms for signalling the increased concentration of impurities in the filtered water. The dilution of the filtered water by clear water in order to reduce the concentration of harmful matter is possible but not permitted, and it should be subject to control. The device should be fitted with a counter of the operating hours so that its constant operation can be easily checked. Depending on the countries on which waters they navigate the laws on treating wastewaters vary, but all the ships that have wastewater filtering devices should have these devices operating constantly.

The third method of treating wastewater, always collecting wastewater and discharging it on the mainland, features two big drawbacks. The first is that the ship needs a substantially big tank for wastewater, and the other is that there are not enough on-shore facilities for the disposal of wastewaters. This method of treating wastewaters is not widely used.

Figure 2 – Pollution by wastewaters

It would be necessary, for complete control of wastewaters and reduction of pollution from ships to zero or near zero, to solve the design of the wastewater system. The wastewater pipelines should all lead to the collecting tank of the wastewaters, and from the wastewater tank into the filtering device and the filtered water should be pumped out of the ship. It is forbidden to discharge wastewater which for any reason contains chemicals, dissolved or suspended which represent a threat to the environment and cannot be eliminated by the devices onboard.

2.3. POLLUTION BY GARBAGE

There are several types of garbage on the ship. Garbage can be generated by domestic activities and as secondary products of the people's stay on board (plastic bottles, food remnants, etc.), may originate from waste and worn out material after completing works on machines and devices (various cloths oiled or not), it may be bulky metal and non-metal parts and pieces (pump housings, engine elements, etc.). In order to prevent uncontrolled behaviour with garbage, the ship has to feature a system for garbage treatment. Garbage needs to be properly collected, stored and treated. The garbage collection facilities have to be installed at certain locations on board and made under the control of the Register. They have to be able to close properly and to enable garbage handling without unnecessary scattering on the floor. The facilities for collection of oiled waste have to be located at special places. The garbage storage facilities also have to be approved by the Register and set into well air premises. The following can be done with the stored garbage: dumping into the river, unloading onto the mainland when the ship is at port, or treatment on the ship without any unnecessary remnants.

In the Croatian waters the first case is the most frequent one, and all the garbage is simply dumped over the railing into the river. This is both ugly to see and may be harmful for health, as well as dangerous for ships and people. When big metal parts of the engines or the very ships are dumped into the shallow river waters, when the draught is low there is the danger that the ship gets damaged on such wrecks. This is also potential danger for the swimmers and people in smaller vessels. Dumping of big parts from the ship is a violation that is difficult to prove and therefore a very frequent case in Croatia.

In Croatia, unloading garbage to the mainland when the ship is at port is a problem. In the ports there

Figure 3 – Pollution by garbage

is infrastructure that could accept and treat garbage, and there is need since the shippers usually have a little garbage since they had dumped everything into the river. This problem should be considered more and every ship should be controlled individually. It is easy to estimate how much garbage a ship produces per one day, depending on the number of people (or) condition of the ship. With precise register from port to port and by verification by every port authority, the quantity of garbage on board may be monitored and controlled, especially plastic.

The garbage on board can be treated in several ways: fragmentation, compression, incineration. Depending on the type of garbage the treatment method is selected. Incineration is a sophisticated method of garbage treatment. The garbage is placed into incinerators that at high temperature (up to1100C) burn all organic matter. The incinerators operate also under the control of the Register. The only restriction is that in this way not all types of garbage can be treated, e.g.: metals, glass, pressurized containers. The most efficient solution is the combination of disposal on mainland and treatment of garbage on board. All the garbage that cannot be destroyed on board has to be unloaded to the reception facilities.

3. CONCLUSION

This paper deals with the pollution issues and prevention of pollution from ships. Unfortunately, proportional to the national wealth and material situation in single countries is the awareness of all those involved in the pollution problems. The situation in Croatia is not as e. g. in all the Danube basin countries eastwards. Of course, Germany and Austria have set very high requirements that our shippers have to comply with when in their waters. It would be good if all the countries accepted the standards of these two countries. Not so long ago, our rivers were clean, suitable both for plant and animal life, and nice for people to stay near them. With a little good will and using the technology of Germany and Austria, Croatia could also take pride in her inland waterways.

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SAŽETAK

ZAŠTITA RIJEKA I JEZERA OD ZAGAĐIVANJA SA BRODOVA

Promet rijekama i jezerima u Europi je jako razvijen. Razlog tome je cijena prijevoza, relativna brzina prijevoza i dobra povezanost većih europskih gradova rijekama i kanalima. U Hrvatskoj je ovaj oblik prijevoza značajno slabiji od ostatka Europe. Hrvatska se nalazi na zanimljivom dijelu riječne transverzale, ali zbog više razloga riječna plovidba u nas nije značajnije razvijena. Kao pogonski riječni brodovi najčešći su: tegljači, gurači i samohodni brodovi. Ugrađeni diesel motori, pogonski i pomoćni, razvijaju velike snage. Proporcionalno rastu snage ugrađenih motora, raste i količina otpadnih tvari koje nastaju radom motora. Također s većom starošću motora, raste količina otpadnih tvari. S brodova su moguća i zagađenja otpadnom vodom i smećem. Ova opasnost zagađenja raste s povećanjem broja ljudi na brodu i sa starošću broda. Da bi se sve ove mogućnosti zagađivanja svele na što je moguće manju mjeru, nužno je konstantno obavljati nadzor nad ispravnošću brodova, obučavati posadu i izgraditi prihvatne uređaje na kopnu.

KLJUČNE RIJEČI

ulja, otpadne vode, otpad, spremnici, pročistači

LITERATURE

[1] Hrvatski registar brodova; *Pravila o sprječavanju zagađivanja*, HRB, Zagreb, 2000.
[2] **Ivaković, Č.** et al.: *Osnove vodnog prometa*. FPZ, Zagreb, 1997.
[3] **Đaković, N.**: *Plovna sredstva u teoriji i praksi*. FPZ, Zagreb, 1998.
[4] MARPOL 73/78 Convention