Assessment of ecological hazards to atmosphere and waters around floating docks in service by using an index method

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ABSTRACT

Identification of ecological hazards was performed on the example of analysis of operational conditions of a floating dock in a ship repair yard. The following issues were described and discussed :

- ✦ *classification and valorization of repair work operations*
- ✦ *alternative ecological engineering processes*
- ✦ *guidelines for designing new environment-friendly docks*
- ✦ *model of environment-friendly dock.*

Keywords : dock designing, engineering processes, environment protection

INTRODUCTION

Activity of ship repair yards generates significant hazards to the environment. Environment protection should be a main obligation strictly integrated with shipyard's manufacturing activity. As long as it is not the fact relevant rules and standards partially regulating the problem must be implemented by order.

An important factor are engineering processes applied to operations carried out on the dock, and their appropriate ecological organization.

In the work in question was performed an analysis of present state of hazards to environment on the example of service of a standard dock used in a selected shipyard. Its scope contained the following problems :

- ➢ identification and valorization of operations and engineering processes which generate hazards to the environment
- ➢ assessment of used docking procedures
- ➢ assessment of dock's technical solutions and equipment intended for environmental protection.

On this basis the proposals of alternative, environment--friendly engineering processes were elaborated. The analysis of existing design solutions was the basis for elaboration of modernization proposals and next the guidelines for designing a new ecological dock.

ESSENCE OF ECOLOGICAL HAZARDS ASSOCIATED WITH SHIP REPAIR WORK ON FLOATING DOCK

A degree of influence of a dock in operation on the environment results from the technical state of the art of its design and engineering processes carried out on it, especially the following issues :

- ⇨ dock's construction
- ⇨ scope and kind of its outfit with devices and systems protecting against environmental pollution
- ⇨ type of operations carried out on the dock
- ⇨ applied engineering processes.

The above mentioned technical and technological problems decide on real effectiveness of pro-ecological activities. In the case of domestic ship repair yards such factors as standards and regulations for environment protection or activity of authorities responsible for environment protection have a very small influence on environment protection effects.

From the complex analysis of hazards to the environment it results that investing in sophisticated environment protecting devices and systems appears very low effective and the outlay of efforts and means appear inadequate to the obtained results, because of a still present unsatisfactory culture of work and a low level of abiding the standards and procedures for environmental protection.

Hence attention should be today paid first of all to applied engineering processes and correct technical state of environment protecting systems and devices installed on existing docks.

The problems associated with environment-friendly course of dock's service should be mainly considered in the aspect of kind of work carried out on docked ship. The dock can be used for :

- ➔ repair of floating units
- ➔ conversion of floating units
- ➔ building new floating units.

The dock itself generates rather low hazard to the environment if it satisfies basic conditions (appropriate construction and equipment) for environment protection as well as if it operates in a way compliant with relevant regulations being in force.

It is important to correctly carry out water and sewage management, to protect against spilling oil products (coming from the dock's internal systems) as well as correct collecting and discharging wastes and garbage produced by the dock's crew.

The currently operating docks much differ to each other in the range of their impact to the environment. The docks built at the turn of 19th and 20th century are scarcely equipped with devices and systems for environment protection. A level of their equipment results from rebuilding its construction and systems in order to comply with relevant standards to a minimum required extent.

On the docks built to operate in the conditions of full cooperation with shipyard's infrastructure as regards their supply with energy media and electric energy from land sources, a degree of their saturation with devices and systems which may have detrimental influence on the environment is lower than in the case of autonomous docks being self-sufficient in maintaining operative and carrying out production.

Main factors which influence the environment around the docks integrated with shipyard's infrastructure, are the following :

- a way in which water and sewage management is carried out
- a degree of protection of waters and atmosphere against pollutants coming from production processes
- environment protection against pollution which may occur in special emergency cases.

Use of the docks for production purposes entails hazards to the environment, which result mainly from realization of engineering processes and operations carried out on a docked object.

To assess the hazards and elaborate appropriate actions aimed at prevention against or reduction of factors harmful for the environment one should define the carried out operations and classify them from the point of view of their harmfulness to the environment. To this end, identification of the repair operations carried out on several ships docked in the selected dock, was performed. The selected dock was assumed representative for the medium class of floating docks as regards their construction (built in 1987) and scope of equipment. An index method for assessment of relative level of hazards was elaborated for purposes of identification of environmental hazards and determination of appropriate preventive actions.

As an environmental hazard measure the following synthetic index was assumed :

$$s = ki$$

where :

k – hazard class expressed in the point scale ranging from 1 to 10 according to the criteria presented in Tab.1

i – three-level hazard intensity factor given in Tab.2.

Tab. 1.

Hazard intensity	Hazard class [in points]
low	1 ÷ 3
medium	4 ÷ 5
high	6 ÷ 8
very high	9 ÷ 10

Tab. 2.

Frequency of occurrence in a process	Hazard intensity factor
sporadically, rarely	1.0
often	1.5
intensively, permanently	2.0

The relative environmental hazard indices for realization of repair operations on the selected dock, are presented in Tab.3.

Tab.3. *Valorization of relative hazard levels for the group of operations most hazardous to the environment .*

No.	Most hazardous engineering processes and operations	Description of operations and processes	Description of hazards to the environment	Hazard class and intensity [points]		Hazard index [points]
				k	i	s
1	Emergency docking of a damaged ship	Sporadically occurring but intensively running	Spill of oil from damaged ship tanks	10	2.0	20
2	Discharge of ballast water from ship tanks	Impossible to be replaced in an other way; it occurs almost always	Contaminations contained in sludge sedimentation or in oiled water	8	1.5	12
3	Ship hull cleaning by using hydraulic monitor	Rather not replaceable by other means; share of several percent	Flow of contaminated water onto the dock's deck and next to surrounding waters	6	1.5	9
4	Removal of paint covering	On the above water part of hull it may be realized beyond the dock; 5 ÷ 15 % share in the entire cycle of work on the dock	Flow of contaminated water out of the dock's deck; dust over water area	7	1.5	10.5
5	Jet painting	On the above water part of hull it may be realized beyond the dock; 15 ÷ 25 % share in the entire cycle of work on the dock	Flow of contaminations from the deck ; paint spreading	6	1.5	9
6	Dock immersion to dock out the ship	Proposals of changes are given; The operation is performed once a docking cycle.	Flow of contaminations from the dock's working deck to surrounding waters	7	1.5	10.5
7	Cleaning of fuel oil tanks	The operation may be carried out beyond the dock; Slight share in the entire amount of work	Spills of oil product pollutants; utilization of wastes	5	2.0	10
8	Fuel oil pumping- over	Sporadically performed to tank the fuel or to discharge it for storing	Spills of oil products on the dock and to surrounding waters	8	2.0	16
9	Propeller shaft disassembling	The operation is performed only on the dock; Several percent share in the dock cycle	Spills of oil product pollutants	3	1.0	3
10	Structure scrapping	Necessary for carrying out hull repair work ; several percent share	Dock's deck contamination, as well as emission of smoke and dust to the atmosphere	3	1.5	4.5
11	Bilge water pumping from the dock	Necessary during service of the dock; sporadically performed	Possible spill of oil product pollutants to the surrounding waters	8	1.0	8
12	Current service of the dock and cleaning its working deck	Current maintenance and repair, and cleaning the dock's deck	Paints, oils, garbage, cleaning materials and wastes, wastes from engineering processes	2	1.5	3

Comparison of the relative hazard levels in the group of most hazardous operations realized on an usual dock and on ecological one are presented in Tab.4.

Tab. 4. *Comparison of relative hazard levels for the group of operations most hazardous to the environment, carried out on an ecological dock and standard one*

No.	Most hazardous engineering processes and operations	Description of hazard lowering factors	Class and intensity of hazards [points]		Hazard index s [points]	
			k	i	ecological dock	standard dock
1	Emergency docking of a damaged ship	Effective barriers around the dock, and environment-protecting bilge water system of the dock	2	2.0	4	20
2	Discharge of ballast water from ship tanks	Effective barriers around the dock, and environment protecting bilge water system of the dock	2	1.5	3	12
3	Ship hull cleaning by using hydraulic monitor	Environment protecting bilge water system of the dock	1	1.5	1.5	9
4	Removal of paint covering	Roofing of the dock, fitted with intake/exhaust ventilation system	2	1.5	3	10.5
5	Jet painting	Roofing of the dock, fitted with in/out flow ventilation system	1	1.5	1.5	9
6	Dock immersion to dock out the ship	Appropriate devices to remove contaminations from the deck of dock	2	1.5	3	10.5
7	Cleaning of fuel oil tanks	Appropriate devices for handling fuel and heavy oil	1	2.0	2	10
8	Fuel oil pumping - over	Appropriate devices for handling fuel and heavy oil	2	2.0	4	16
9	Propeller shaft disassembling	Devices for removing oil spills, environment protecting bilge water system of the dock	1	1.0	1	3
10	Structure scrapping	Roofing of the dock, fitted with intake/exhaust ventilation system	2	1.5	3	4.5
11	Bilge water pumping from the dock	Environment protecting bilge water system of the dock	2	1.0	2	8
12	Current service of the dock and cleaning its working deck	Roofing of the dock, environment protecting bilge water system of the dock	1	1.0	1	3
		Total :	**19**	**18**	**29**	**115.5**

ALTERNATIVE ENGINEERING PROCESSES

Identification of operations having the highest relative hazard level is the basis for determining the hierarchy of preventive actions, namely :

- ★ moving such operations beyond the dock, to a workshop
- ★ applying alternative engineering processes and materials
- ★ assessing rationality of investment undertakings (purchase of new equipment, modernization of dock's facilities etc.).

The problem of replacement of troublesome engineering processes by alternative, environment-friendly ones, becomes especially important because of high cost of devices for neutralization of contaminations. In present it deals first of all with a way of carrying out preventive painting operations on docked ship's hull. Great attention should be paid to application of environment-friendly working materials (appropriate abrasive materials, paints based on non-noxious solvents and components).

The engineering processes so far applied to such operations should be replaced by more ecological ones and less troublesome for their direct executors. Instead of the traditional way of removing old paint coverings by means of the dry grinding method with the use of portable grinding tools or open-cycle sand, electro-corundum or copper slag blasting, the closed-cycle blast cleaning processes, e.g. by using special facilities or closed chambers, as well as „wet sand" blasting should be applied. In this process only the final stage of hull cleaning is allowed to be performed by using an open-cycle „dry" jet in the case if the high cleanness class of surface prepared for painting (SA 2.5 class) is required. In 2003 the open-cycle dry sand blasting was banned in Poland, like in neighbouring countries.

Ship equipment elements which can be disassembled (e.g. hatch covers) as well as other steel structures made on the dock itself or shipyard's quay , should be cleaned and preserved in closed chambers. Despite the associated increase of direct manufacturing cost it is possible to obtain a positive economical result due to accounting for an improvement of workmanship quality of operations, their prompt realization as well as a decrease of environment pollution penalties.

For ship hull cleaning the „hydroblasting" method by using water jet under a very high pressure (over 2500 bar) is recommended , which substantially lowers a range of further dry jet blasting, or even entirely eliminates it in the case if a high cleanness class of surface preparation prior painting is required.

Amount of water consumed in the UHP (Ultra High Pressure) cleaning process is much smaller, accompanied with much higher effectiveness of the process, than the amount consumed in the traditional use of hydraulic monitors installed on the dock.

The modern high pressure devices are fitted with their own system for collecting used water as well as for separating solid wastes (paints , corrosion products) produced during hull cleaning. The wastes are collected in a separator by means of an under-pressure system. The UHP process is friendly for the environment and direct operators as well, and much more effective than an open dry-jet cleaning process. It is also favourable for quality and durability of a new paint covering as it effectively removes sea salt deposits from cleaned hull surface.

GENERAL GUIDELINES FOR DESIGNING NEW ENVIRONMENT - FRIENDLY DOCKS

In real investment conditions the problem of choice of a type and size of a dock is dependent on natural conditions and hydraulic engineering possibilities of building such technical facility, and it results from a type and size of floating units intended to be dominating in profile of production or repair work carried out by a given shipyard. The crucial choice is to determine a type of dock : whether dry or floating one.

For the dry dock it is easier to provide working conditions similar to those prevailing in workshops. Full roofing and sheltering the floating dock is technically difficult and costly. Moreover such covering is to fulfill strength conditions under strong wind and snow loads, as well as requirements for dock's stability and lifting capability. Even though in the existing shipyards there is no floating dock with full roofing , and equipped with facilities satisfying all environment protection criteria, it can be stated that to build a relatively small-size, environment-friendly floating dock is possible. Because of technical difficulties and financial costs connected with building or full modernization of an ecological floating dock its optimum lifting capacity and size may be determined as follows :

- ➡ lifting capacity of the dock – a few thousand tons
- ➡ length of ships to be docked – up to a hundred meters.

General assumptions

A new dock should comply
with the following conditions :

- ❖ As far as its construction and equipment is concerned it has to comply with the criteria given in regulations of international institutions (IMO) and classification societies, „Marpol" 73/78 International Convention, as well as home port regulations.
- ❖ Procedures and manuals binding in carrying out work on the dock and its current service have to be elaborated on the basis of the above mentioned regulations and in compliance with the principles of work safety and environment protection.
- ❖ A monolithic structure of the dock is recommended as tightness of its working deck is required for the reason of control of purity of the water flowing from the deck to the surrounding waters.
- ❖ Length of the dock should be greater than the overall length of to-be-docked ships so as to make sheltering the dock by means of closed aft and fore curtains effective.
- ❖ Equipment of the dock with combustion devices (electric generating sets, compressors) and other ones (boilers) which increase hazards to the environment, should be reduced to a minimum. It may be obtained e.g. by connecting the dock with shipyard's energy infrastructure, to possibly largest extent.
- ❖ Such dock's system of supply from land sources should satisfy whole energy demand for carrying out production operations and current service of the dock. The emergency lighting network of the dock should have an additional supply source from an accumulator battery.

The following media should be supplied
from land sources :

- ⅄ electric energy
- ⅄ heat energy
- ⅄ compressed air
- ⅄ oxygen and acetylene
  (or another combustible gas)
- ⅄ fresh and tap water
- ⅄ working water
  (for ship ballasting)

- ❖ A range of outfit of the dock with sanitary and living systems is determined during its design phase, depending on shipyard's conditions. If in the shipyard in question the infrastructure for sewage and waste collecting and treatment is well developed then to double it on the dock is unnecessary. In such case the dock's systems of the kind should be reduced to a minimum reflecting only the needs of crews of the dock and docked ship. In the case if possible discharging of sewage and waste water to a land-based system is limited then the dock is to be fully equipped with relevant systems complying with the rules binding for sea-going ships.
- ❖ The dock is to be fitted with an environment protecting bilge water system as well as it should be capable of developing an oil boom.
- ❖ The dock should be adjusted to installing, in the future, its full roofing and sheltering by means of front and side curtains, or dismantleable roof segments.

Moreover a new ecological dock should have :

- ✓ properly secured outlets and terminals of fuel oil and sanitary liquid systems
- ✓ alarm systems for signalling excessive emission of gas pollutants, discharge of oily water and oil itself
- ✓ gear for ship's hull high-pressure washing
- ✓ tanks and containers for collecting wastes, as well as a gear for neutralization and removal of oil and chemical pollutants.

During designing a new dock it is possible to account
for the following additional design solutions :

- ⟐ installing the dock's systems in dry, easily accessible ducts placed above or between ballast tanks of the dock
- ⟐ full heating the working compartments and insulating their walls to reduce failures possible in winter conditions as a result of freezing and cracking the piping systems
- ⟐ applying the gantry cranes instead of typical dock cranes
- ⟐ applying the dust and gas exhaust ventilation systems installed in dock's side walls and under its roofing.

MODEL OF ENVIRONMENT-FRIENDLY DOCK

The problem of rational limitations for design solutions of ecological docks should be solved by introduction of the notion of ***a model of ecological dock***. And, two its models should be distinguished :

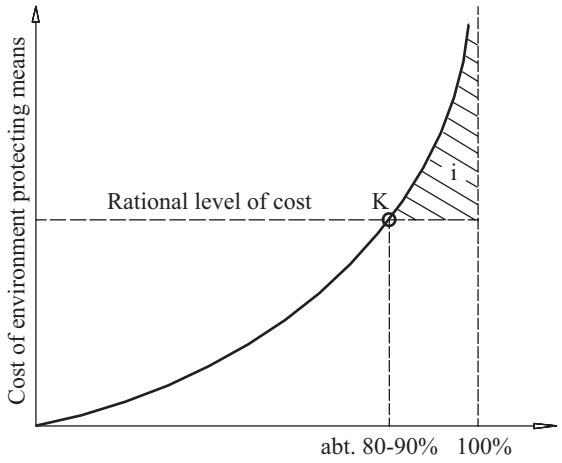
- ✪ **IDEAL ONE**
- ✪ **REAL ONE**

The models are defined as follows :

- ☆ **IDEAL MODEL** – an independent design solution which contains about all environment protective means against full set of dock's operational hazards
- ☆ **REAL (RATIONAL) MODEL** – a dependent design solution tailored to meet conditions of a given shipyard with accounting for rational technical and economical limitations. It has to cover a rational scope of environment protecting means for real (rational) set of dock's operational hazards.

The ideal model forms a model space for design solutions which may serve as a reference space for real designs.

The graphical illustration of the proposed design idea of ecological dock is presented in Figure.



Graphical illustration of the ecological model idea.
***Notes** : **K** – critical point for rational design solutions;*
***i** – area of irrational actions .*

FINAL REMARKS

- ❍ Scientific research work on an ***ideal model of ecological dock*** should be continued as it presents a design solution independent of technical and economical limitations existing in today ship repair yards. Such solution free from the present limitations will be a proper reference space for real dock designs.
- ❍ Apart from the above mentioned work similar research should be carried out on the ***real models*** to reveal sources of existing problems and barriers against their solving.
- ❍ The area of irrational design activity, shown as the area „i" in Figure, should be practically removed by technical organizational actions aimed at eliminating unwanted hazards.
- ❍ In the conditions of today ship repair yards, any investment into tools and gear for realization of engineering processes should be accompanied with „investment" into process management technology. The process management system should be fully integrated with comprehensive activity aimed at environment protection, in all realization phases of ship repair undertaking (i.e. offering, contracting, designing dock's construction and technology, realization of repair work and evaluation of its processes).

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