Ecological floating dock

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ABSTRACT

This paper presents final results of E!2968 EUREKA – ECOLOGICAL DOCK project sponsored by the Polish State Scientific Research Committee. The consortium established for realization of the project is presented, ecological hazards are characterized, the most important legal regulations are specified, as well the design of the ecological floating dock SINE 212CD and a concept of conversion of the existing dock SINE 126CD to the class CLEAN is characterized. The paper also contains the complete bibliography of the elaborations done within the project. More information can be found on the web page www.oce.pg.gda.pl/oce2/eureka . This paper opens the series of the selected publications on various problems solved in the frame of the project, which are presented below.

Keywords : EUREKA – ECOLOGICAL DOCK project,
structural strength, construction, technology, designing, ecological problems

INTRODUCTION

Environment safety problems begin to play more and more important role in the world economy. The tendency is also reflected in paying attention to designing the environment-friendly transport means including those for sea and inland waterways shipping, as well as to creating technical infrastructure suitable for their production and operation, and relevant legal background.

The widely spread status of environment-friendly short--voyage ships operating on relatively short shipping coastal routes or in restricted waters, is accompanied with the necessity of developing such technical infrastructure for building and repairing these ships, which could satisfy contemporary demands for environmental protection. This paper deals with the above mentioned problem in the frame of which is presented a design proposal for the medium- size ecological floating dock as well as a design concept of such conversion of one of the floating docks operated in Poland to fulfil ring the ecological „cleanness" requirements. Both the proposals are recommended to the readers' attention as a possible alternative of building a launching facility both for the shipyards having problems with building, repairing and launching the ships (as a result of lack of terrains or progressing decapitalization) and for currently organized enterprises of shipbuilding industry, not having at their disposal any ship launching facility.

AIM OF THE PROJECT

In order to create a design vision of an ecological floating dock for the Baltic Sea the European project called „Environment Friendly Floating Dock" E!2968 has been established within EUREKA group. Apart from the preliminary design of floating dock, based on broad topical studies, it was also necessary to elaborate the design concept of conversion of one of the existing docks to assign the class *Environmental Clean* to it. Moreover some measurements on the state of environmental pollution in the area of operation of the floating dock in question had to be performed in shipyard, environment-friendly engineering processes to be selected, as well as mechanisms and systems which could ensure environmentally safe operation of the floating dock to be analysed.

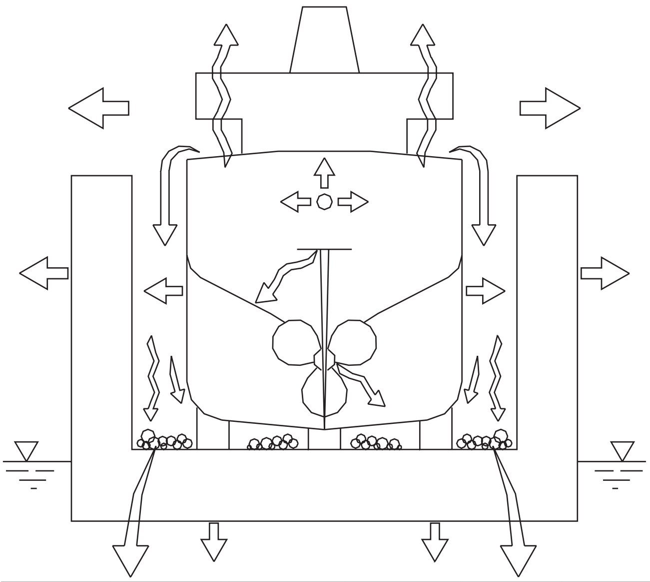
STRUCTURE OF THE PROJECT

The realization consortium has been set up as follows :

- ❖ Faculty of Ocean Engineering and Ship Technology, Gdańsk University of Technology was assigned the coordinator of the whole project and executor of : design assumptions for the dock, technical studies concerning structure, strength, reliability and safety, technological feasibility assessment, and design of special systems for the ecological dock.
- ❖ Faculty of Environment Engineering, Warsaw University of Technology – the executor of : studies on technical and physical problems of environmental protection associated with operation of floating docks.
- ❖ SINUS Design Office, Co Ltd – the author of technical solutions for the ecological floating dock, as well as of the design concept of conversion of existing floating dock.
- ❖ Gdynia Naval Shipyard – a participant of an ecological monitoring task.
- ❖ Gdańsk Maritime Shipyard – a participant of an ecological monitoring task.
- ❖ Innowative Fertigung Infert (a German company) – a consultant.
- ❖ Polish Register of Shipping – a consultant and the author of a draft proposal for classification rules for ecological docks.

ECOLOGICAL HAZARDS GENERATED BY FLOATING DOCKS

Floating dock's operation creates significant hazards to environment. They generally amount to various emissions and pollutions (Fig. 1) or production of solid wastes resulting from engineering processes of repair work, moreover a part of the substances or their components is cumulated in water bed sediments in the area of dock's operation and their rest dispose to the atmosphere or water, and is thus spread over a greater area. Docked ship is also a source of hazards as it generates threat of non-controlled discharge and emission of e.g. liquid working media (fuels, oils, lubricants, contaminated ballast water, sewage, cooling liquids, cargo residues) or gaseous substances remaining in empty holds, tanks and installations. The threat significantly grows especially in the case of docking the floating units of failed hull structure or functional systems. Hazards generated by the ship itself depend on its kind and size. At last, the floating dock itself may be a source of environmental pollution e.g. due to discharged ballast water, leakage from its systems and connecting pipe lines, operational materials used in its facilities and systems, its own paint coatings, scrap materials or residues from operation of the dock's systems.



Possible environmental pollution produced by floating dock

Emission of :	
dust of abrasive materials	
paint particles	
vapours	welding gases
chemical compounds	

Discharge or leakage of :	
sewage	solutions
emulsions	mixtures
oil products	synthetic oils

Solid wastes :
biological
abrasive materials
paint flakes
corrosion products
welding materials

Fig.1. *Schematic diagram of non-controlled hazards to environment resulting from ship's hull repair operations carried out on the dock .*

The hazardous phenomena resulting from floating dock operations are not subjected to systematic control, they have not been so far precisely defined and have found only a limited relation to legal and technical regulations. It mainly results from an aversion of industrial circles to reveal the ecologically unfavourable side effects of their activity. Generally, the greatest attention should be paid to effects of carried-out engineering processes and produced scrap materials. Penetration of noxious substances to environment may be reduced by :

1. covering (sheltering) the whole dock by means of a mobile roof structure
2. applying local modular stiff paravans to protect ship hull fragments or even the entire hull
3. temporary sheltering the ship by canvas or plastic covers
4. applying, when running some engineering processes, special systems and/or machines with closed circulation of working media and gathering wastes in a system of containers being an integral replaceable part of the machine or a separate unit
5. removal of production wastes with the use of separate special floating units adjusted to recycling them on board or carrying to land-based waste stations equipped with recycling and utilizing systems
6. limitation of development of new independent, waste--generating dock systems in which only a few emergency systems are left and most of working media used on the dock are taken out through special service lines belonging to land stations
7. arrangement of special local stations to prevent from propagation pollutions occurred in emergency situations.

Effectiveness of application of the means 1,2 and 3 depends on effective isolation (separation) of working spaces. It is automatically associated with the necessity of application of additional ventilating, filtering and warning systems to eliminate possible appearance of dangerous concentration of gases inside dock's protective encasings, as well as application of systems for gathering and removal other liquid, semi-liquid and solid wastes (items 4,5 and 6).

General complex application of the means effectively preventing the environment against pollution may appear too expensive for operators of only one dock as in the case of small shipyards able to apply only simple temporary means of a low effectiveness. In the areas of concentration of ship repair and shipbuilding industry it seems justified to arrange special common centres for collection, transport, processing and utilization of waste substances hazardous for water, land and air environment, that obviously could ensure a professional, high-level effectiveness of their activity.

Out of the engineering processes which are specially hazardous to environment the following may be distinguished :

- ✓ initial washing
- ✓ removal from construction of fouling, old coating flakes and corrosion products
- ✓ washing the construction in advance of painting
- ✓ painting the construction
- ✓ welding, thermal cutting and straightening
- ✓ luting and grinding
- ✓ insulating.

The processes may be carried out with the use of various techniques and methods and should be selected with accounting for their as-low – as-possible harmfulness to the environment, that may appear expensive. Hence it is clear that it cannot be an immediate narrow-ranging activity but it must be a result of complex long-ranging actions often involving investment outlays.

HARMFUL SUBSTANCES

A few measurement series have been performed for the project's purposes because any systematic data on monitoring the state of ecological hazards in the areas of operation of floating docks, are lacking. They have served for qualitative and quantitative determination of sewage and waste streams generated in the course of repair work on ships of three different types.

a) In the range of emission to the atmosphere:
- dust of abrasive materials (uncontrolled discharge) – content of compounds of the metals: zinc, iron, copper, lead
- volatile components of paints and solvents (uncontrolled discharge) – content of : xylene, aliphatic hydrocarbons, butyl acetate, ethylic benzene, phenol
- gas emission resulting from operation of dock's energy systems – content of : NO_x , SO_x
- emission resulting from welding processes – content of : CO , NO_2 , dust containing Fe_2O_3 and MnO.

In the case of the sheltered working space of the dock, disposal and utilization of xylene vapours as well as dust and smoke is especially important.

b) In the range of pollution of water around the docks – after completion of repair work: the increase of content of the metals : cadmium (4 times), zinc (2 times), nickel, copper, chromium, cobalt and manganese (2 times each).

c) In the range of water bed sediments of abt 30 cm in depth – in the area of dock's basin a large content of mineral substances and significant contamination with heavy metals (zinc, copper, lead, nickel, manganese) and iron has been observed. Also, aromatic hydrocarbons and tin organic compounds have been found.

d) In the range of liquid wastes due to:
- preliminary washing – high content of suspended matter, dry residues and COD (Chemical Oxygen Demend) organic nitrogen and phosphor, chlorides and sulphides
- bilge water – high content of oil derivatives as well as COD, tin organic compounds and heavy metals (cobalt, zinc, copper) and iron.

e) In the range of solid wastes:
- after washing – oil derivatives, heavy metals (copper, zinc, lead) which in principle belong to the category of harmful wastes
- after abrasive jet working – high content of iron, lead, zinc, copper; which in principle belong to the category of harmful wastes.

LEGAL REGULATIONS

In the considered case are in force the legal regulations concerning shipping and ports such as : MARPOL 1974/78 International Convention, the Convention on Prevention of Marine Pollution by Dumping of Wastes and Other Matter (1972), London Convention OPRC (1990), Helsinki Convention on Prevention of Baltic Sea Environment (1992), IMO Act for the Prevention of Pollution from Ships (1995), Rules of the classification societies such as DNV, LR, ABS and GL, relating to the requirements for ecological ships, Polish State Act on Prevention of Environment (2000), the Decree of Ministry of Infrastructure relating to port plans on managing the wastes (2002), as well as that on reporting about functioning the port facilities for picking-up the wastes (2002), European Union Directives on the Limitation of Volatile Organic Compounds (VOC) (valid from 1.06.2001) limiting the application of paints containing harmful solvents, IMO Resolution A 895 which fully prohibits the application of paints based on TBT compounds (valid from 1.01.2008). From the above given specification it results that special ecological problems of floating docks should be covered by one uniform legal act.

CHARACTERISTICS OF THE DOCK

The designed dock SINE 212CD (Fig.2 and 3) consists of an integral box structure composed of pontoon and two continuous side walls. The dock is fitted with 6 ballast compartments of 4 ballast tanks each. In the dock's structure has been provided 3 longitudinal watertight bulkheads (of 13 mm plate thickness), 5 transverse watertight bulkheads (of 10 , 12 and 14 mm plate thickness, respectively) as well as 28 transverse non – watertight bulkheads (of 10 and 14 mm thickness, respectively). In the pontoon is located the transverse cable duct (having gabarites of 1780x1940x10 mm) which connects relevant casings in the side walls, the bottom (of 10, 11, 12 and 13 mm plate thickness) and the deck (of 10 , 12 and 14 mm plate thickness). Each of the dock's side pontoons (of the dimensions of 170000x4000x9750 and shell plating thickness 8 or 10 mm have 2 decks: the upper deck (of 24 mm plating) and safety deck (of 9 mm plating), 5 transverse bulkheads (of 10 mm plating), tanks, inspection and cable casings, gangways, 1 outer and 2 inner fenders, overflow and access recesses. In order to improve the dock's stability, the sponsons (of 10 mm plating) have been provided on the outer side structure at the pontoon's deck height. On the dock's side walls a continuous framework has been assembled, on which 6 movable roof segments sheltering the dock are placed. The segments were so designed as to obtain the units of two different depths and breaths, that makes it possible to slide one over another (to change windage area or to enable transport of elements to the dock working space). The segment roofing and side coverings of framework as well as shutter-like coverings of end roof segments are aimed at limitation of emission of harmful substances to the atmosphere and effective improvement of working conditions. On the framework a 160 kN lifting capacity gantry crane operates. The side pontoons have the so called *coastings* (10 m long and of 10 mm plating thickness and the dock's end platforms (10 m long and of 12 mm shell plating, aft, and 5.725 m long and of 12 mm plating, fore) are fixed to the pontoon. The side pontoons are connected together by means of a two-wing passageway.

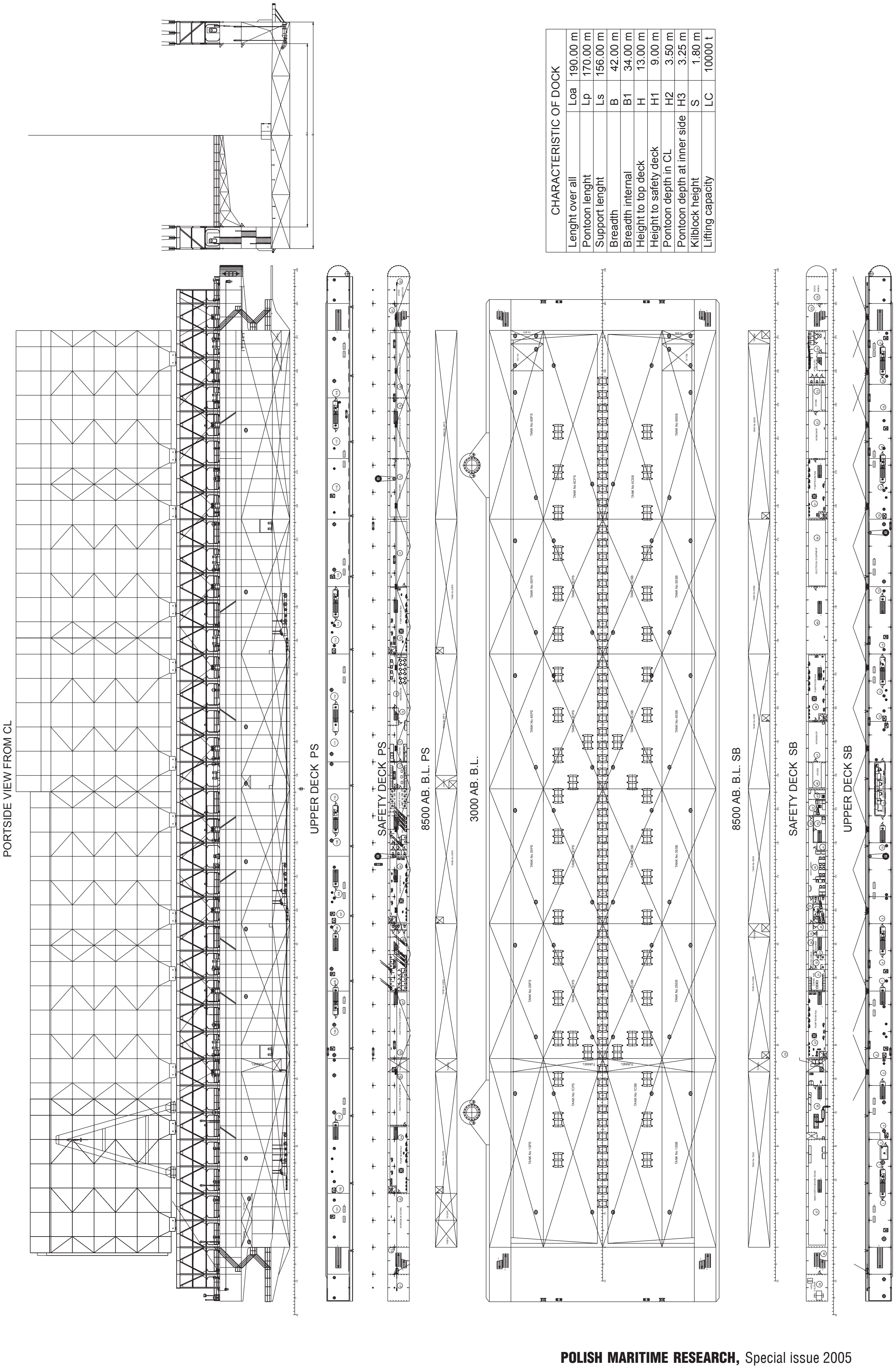
Particulars of the dock :

total length	L_c	= 190.0 m
pontoon length	L_p	= 170.0 m
outer breadth	B_z	= 42.0 m
inner breadth	B_w	= 34.0 m
pontoon depth	H_{ps}	= 3.5 m
pontoon depth at side wall	H_{bs}	= 3.25 m
depth to safety deck		– 9.0 m
depth to upper deck		– 13.0 m
height of keelblocks		– 1.8 m

dock's load-carrying capacity : 10 000 t

dock's load – carrying capacity at the draught T = 3.06 m : 13 715 t

- The minimum freeboard of the immersed dock : >1.5 m; and the freeboard of the emerged dock (pontoon) measured at the inner side wall plating : ≥0.2 m
- The maximum values of dimensions of docked objects :
  - total length L_c = 169.0 m under full roofing, and
  - L = 185 m at slid-over end roof segments
  - maximum draught T_{max} = 5.8 m
  - maximum mass – 10 000 t



CHARACTERISTIC OF DOCK		
Lenght over all	Loa	190.00 m
Pontoon lenght	Lp	170.00 m
Support lenght	Ls	156.00 m
Breadth	B	42.00 m
Breadth internal	B1	34.00 m
Height to top deck	H	13.00 m
Height to safety deck	H1	9.00 m
Pontoon depth in CL	H2	3.50 m
Pontoon depth at inner side	H3	3.25 m
Kilblock height	S	1.80 m
Lifting capacity	LC	10000 t

***Fig.2.** Simplified general arrangement plan of the SINE 212CD dock .*

- The dock is moored to 2 dolphins on PS
- Deck equipment : four 80 kN capstans, two mobile pulling cars, on PS and SB, together with 100 kN warping winches for leading the ship into the dock, put-in personnel & load elevator (PS) of 10 kN hoisting capacity, fenders, mooring bollards and fairleads
- Three options of electric energy supply have been provided (2 from land sources, and 1 from own electric generating set)
- Dock's power plant: one electric generating set of 140 kW at 1500 rpm, oil fuel tank, cooling water surge tank
- Pump stations: 3 in each of the side pontoons, fitted with a mechanical intake ventilating system. The pump stations are equipped with a motor driving ballast pump, drives of the main and controllable gate valves for ballast water and its residues, bilge pump of the capacity Q = 6 m^3/h, at the pumping pressure H = 0.2 MPa
- Mechanical workshop: locksmith and welding equipment.

Functional systems :

- Ballast system – 6 ballast pumps of 2400 m^3/h capacity each, at H = 0,07 MPa, 2 residual water deep-well pumps of 90 m^3/h capacity, at H = 0.2 MPa, which may operate as 60m^3/h fire pumps, at H = 0.8 MPa
- Water fire main system intended also to support a froth-smoothering system
- Froth-smoothering system : frothing agent tank of the capacity V = 5m^3, two 9.5 m^3/h water pumps
- CO_2 fire-extinguishing system : the station of five CO_2 cylinders, of the capacity V = 67 l
- Steam system – supplied from a land source
- Sanitary system – fresh water supply piping from a land source, sterilizer, electric heater, 2 circulation pumps of 1.8 m^3/h and 3.6 m^3/h capacity, respectively
- Sewerage system – sewage is pumped away from TK9PS tank to a land-based tank
- Compressed air system – supplied from a land-based compressed air station
- Acetylene pipeline system : supplied from a land-based acetylene station
- Oxygen pipeline system : supplied from a land-based oxygen station
- Light water system : supplied from a land source
- Bilge water system – 7 bilge water pumps of 6 m^3/h capacity each, located in pump stations and pumping the water to a dock's tank and from here away to a land- based tank
- Drainage system – taking water from the framed upper deck and pontoon deck – through catch gates and piping to the pontoon deck and further to oily-water and non-oily water tanks. The tanks are emptied with the use of pumps bringing the water away to land
- Electric generating set's cooling system – of two stages : with fresh water (closed) and overboard water (open)
- Fuel oil system – through a service tank
- Exhaust gas system – through an insulated pipeline to the atmosphere, behind the dock's structure
- Ventilating system (servicing the accommodations) : a mechanical supply-exhaust system with outlet to the dock chamber space and from here by using fans (14 units of 11.3 m^3/h capacity each) and special filters – overboard to the atmosphere
- Electric power system – the main supply from a land-based electric station of 3x15 kV at 50 Hz frequency, and 3x400 V. The maximum power output of 15 kV network : 640 kW (800 kVA), the maximum power output of devices fed from 400 V land-based electric network : 80 kW (10 kVA). Simultaneous supply from both the networks is not provided for. On the dock a 15 kV connection switchboard and 0.4 kV transformer feeding 400 V main switching station, are installed. The 3x230 V/50 Hz network is fed from a 200 kVA main transformer as well as from 40kVA emergency transformer.

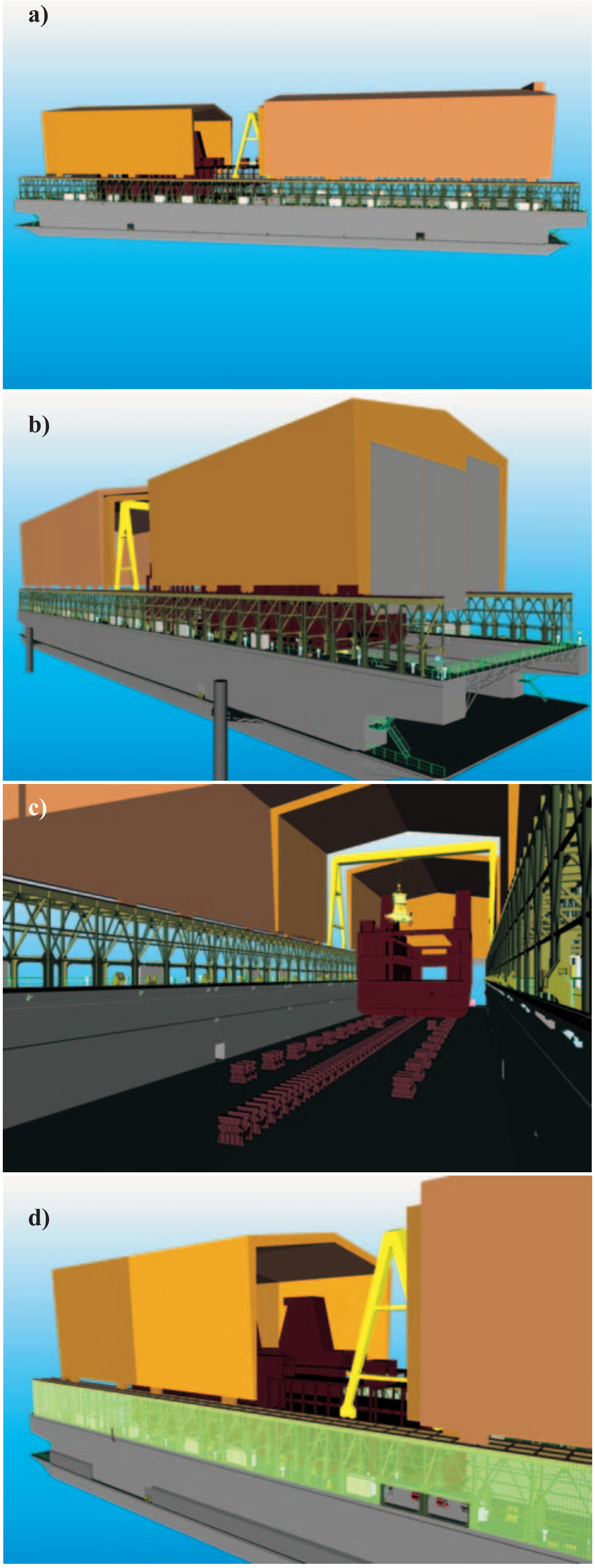


***Fig.3.** Selected examples of virtual visualisation of the SINE 212CD dock : **a)** general view; **b)** shutter-like coverings of end roof segments; **c)** the framework assembled on the dock's side walls; **d)** sponsons and the light passing through framework covers .*

CHARACTERISTIC OF DOCK		
Lenght over all	Loa	151.00 m
Pontoon lenght	Lp	140.40 m
Support lenght	Ls	135.72 m
Breadth total (without dolphins, with sponsons)	B1	39.40 m
Breadth	B	35.50 m
Height to top deck	H	14.50 m
Height to safety deck	H1	10.50 m
Pontoon depth in CL	H2	3.50 m
Pontoon depth at side	H3	3.50 m
Kilblock height	S	1.80 m
Lifting capacity	LC	10000 t

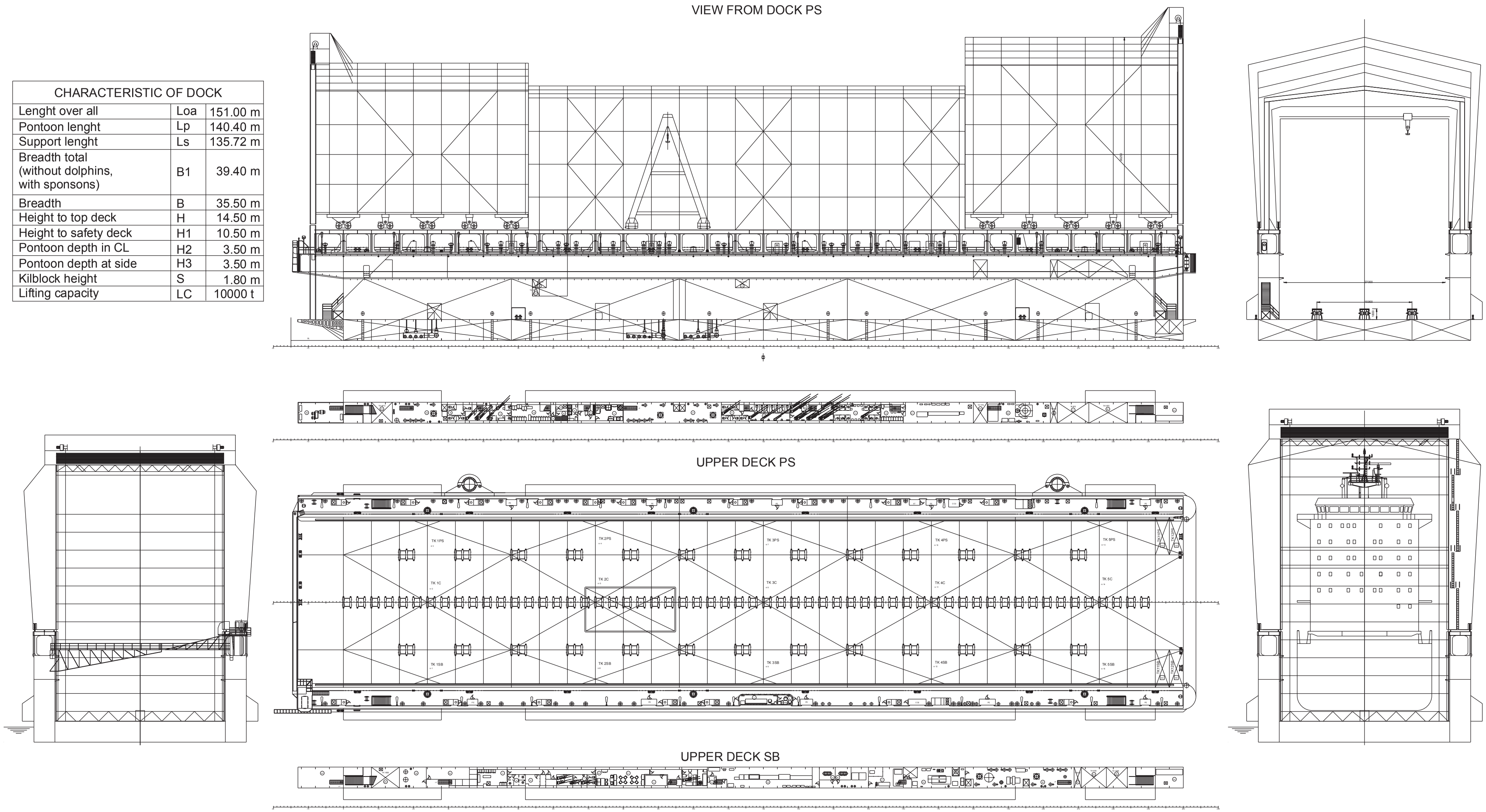


Fig.4. Characteristics of the converted dock .

CHARACTERISTICS OF THE CONVERTED DOCK

The design concept of pro-ecological modernization of the SINE 126CD dock (Fig.4) concerns the existing unit of the following particulars :

total length L_c = 151.0 m
outer breadth B_z = 35.5 m
max. draught T_{max} = 13.3 m
inner breadth (between sides pontoons) – B_K – 28.5 m
height of side pontoons – 14.5 m
height to safety deck – 10.5 m
load-carrying capacity – 8000 t
hoisting service – 2 cranes.

The design concept of the dock's modernisation amounts to :

- assembling 4 m deep continuous frameworks on the upper decks of side walls
- adding three blocks of segments of dock's roofing, two end segments of which fitted with shutter-like coverings are movable and have different heights so as to make it possible to slide them over the main, middle part of the roofing
- introduction of the side wall sponsons to improve the dock's stability
- adding 4 tanks for sewage and waste water, of 35 m^3 each
- adding one 160 kN gantry crane
- adding the ship pulling-in devices moving along the side walls
- modification of run of some stairs
- adding the mechanisms to move the roof segments
- adding the framing of side wall main decks, and pontoon deck
- introduction of a separate ventilating system consisted of 16 ventilating units fitted with special filters against xylene vapour lingering in under-roof space
- adding a biological sewage treatment station
- installation, in the region of the added sewage tanks, a local piping system to discharge their content into sewage tender cars, with the use of a mobile pneumatic pump.

It has been proposed to gather solid wastes mechanically and discharge them to land for further processing. Suspension waters and mixtures should be in advance processed in the additional tanks from where the cleaned-up water flows down to overboard waters, and the sluge is delivered to land. As a result of the proposed changes the PRS class **dk dok ekologiczny* can be assigned to the dock in question. Also, the dock obtains the following new main particulars :

- total breadth including sponsons – 39.4 m
- breadth of dock's roofing – 38.9 m
- maximum side height above waterline – 52.6 m
- load-carrying capacity of the dock
- elimination of to-be-docked ships of about 80 m length and 8000 t mass in order to satisfy longitudinal strength criteria for the dock.

The following factors may limit safe working conditions of the dock :

- necessity of strengthening the upper deck of side walls by means of girders
- necessity of strengthening the pontoon's longitudinal structure
- limitation of possible docking operation of the ships to the wind force less than 17.8 m/s for ships 80 m long and of 8000 t mass (to satisfy the longitudinal strength criteria).

SUMMARY

Conclusions concerning SINE 212CD dock

The movable roofing of the floating dock, proposed in the design as a permanent structural element to prevent the atmosphere from emission of harmful substances, has its advantages and disadvantages. To the advantages one should count stable conditions for realization of engineering processes, and making them independent of atmospheric exposures. A disadvantage is a significant rise of the centre of lateral pressure of the dock and its centre of gravity, as well as an increase of the docks deadweight by the weight of roof structure and an additional casual weight of snow (stability), that results in the necessity of application of sponsons to broaden dock's waterplane, and simultaneously limits the effective load-carrying capacity of the dock. The problems involved by roofing the dock may be omitted by applying modular structural paravans to be used only during the operations especially harmful to the environment. However, even if any mode of sheltering is applied, the most effective way is to reduce emission of dust and paint particles to the atmosphere. The problem of concentration of solvents and paint particles within the enclosed space of the dock becomes more and more observable. Concentration of xylene may be a problem as it occurs close to the pontoon deck and its removing requires additional ventilating ducts located in lower parts of the side wall inner plating and the expensive mobile ventilating and filtering stations. The problem can be effectively solved by replacing harmful paints with paints containing solvents based on water or carbon dioxide, in compliance with European Union directives. As far as the paints which pollute surrounding waters are concerned a far-reaching solution would be to resign from application of TBT paints and replace them either with less noxious copper paints, coverings of high smoothness or future paints containing biocides. It seems reasonable to widen the use of methods of paint hydrodynamic spraying with air support or HVLP (low pressure) spraying, which lead to significant limitation of paint spattering by over 80% and 75%, respectively, and to a reduced emission of solvents. In the range of noxious emission due to welding the „low-smoking" and gas-shielded welding techniques accompanied by local mobile ventilating systems should be decidedly introduced. It seems essential to introduce systems for monitoring harmful concentration and emission to the atmosphere.

The problem of solid wastes of different origins seems to require a comprehensive solution, outside the dock's working area. In general, to this end the currently used solution based on the floating or wheeled waste removal units may be further applied on the condition that the problem of mechanical gathering the wastes from the dock's working space associated with successive washing both ship's structures and dock's working surfaces, is effectively solved with accounting for that the resulting liquid and suspension sewage would be collected in the bilge-tank system and then discharged to land. It seems also reasonable to elaborate a design concept of a facility for storing and processing ecologically harmful wastes, common for a greater number of shipyards.

Conclusions concerning the conversion of the existing dock

To protect the environment against emission of harmful substances from the dock in question is possible by applying :

- ✓ total structural roofing of the dock
- ✓ absorption and utilization of harmful gases, dusts and solid substances.

The application of the movable end parts of dock's covering would make it possible :

- to significantly reduce lateral windage area during ship's docking operation
- to ease free access to end parts of the dock (repaired ship) from the side of water area
- to bring the ships having high aft superstructures into the dock.

The reduction of lateral windage area by sliding the movable roofing parts over the middle ones and the addition of sponsons prevents the dock from exceeding the heel angle of 1.5^o under the wind pressure p = 490 Pa (abt. 20 m/s wind force), permissible for the considered dock acc. to PRS rules. Docking the ships of abt. 80 m in length and the nominal weight of abt. 8000 t may be permitted at the wind pressure not greater than 413 Pa (abt. 17.8 m/s wind force). Control calculations have confirmed that the elaborated dock roofing design is feasible. However the design should be further developed with a view of the following problems :

- moving and fixing, at given positions, the movable roof segments
- a way of removing snow layer from the dock's roofing, especially from its middle part, since an excessive snow layer could prevent the movable roof segments from motion.

Provisionally the two ways were considered :

- to provide for a heating system located just under the roofing
- to direct heat air flow towards the roofing.

The first way is easy in use but expensive, whereas the second is characterized by a large heat dissipation and lower effectiveness, but in return it rises temperature within the whole space (compartment).

However the structural analysis of the dock, performed on the basis of spatial beam model, consisting in longitudinal, transverse and local strength calculations (acc. PRS rules) leads to the following conclusions :

- In the analysed loading conditions of the dock the pontoon's centre girder and plate floors in its vicinity show a great overloading over almost the whole length of the dock
- The longitudinal strength of the dock is ensured for docking the ships less than 80 m long and of the weight equal to the nominal load – carrying capacity of the dock but decreased by the weight of roofing and coverings.

In order to maintain the current range of operation of the dock its hull should be strengthened. The two following methods of rebuilding (strengthening) the dock may be effective :

a) to cut the dock close to its plane of symmetry and add the next centre girder together with neighbouring parts of plate floors

b) to design a new pontoon with making use of the existing side walls of the dock.

Perhaps, the method **a)** is less expensive and labour-consuming in realization but it does not guarantee any long service-time for the dock because of the developed corrosion process of its structure. An additional transverse strength analysis of the dock could provide indications on by how much it would be possible to broaden the dock and if it would be sufficient to satisfy stability criteria for the dock without adding the sponsons, that is rather doubtful. Furthermore any increase of the pontoon's breadth would result in an increased breadth of dock's roofing, and in consequence, in an increase of scantlings of its structural members and thus also its weight etc.

The method **b)** makes it possible to design the pontoon in an optimum way, that could provide the dock with an appropriate service range.

Also, effectiveness of the method of dock's mooring to dolphins should be checked, and the problem of uniform distribution of weight of the movable part of the dock's roofing (by making its side walls more flexible and increasing the number of driving car units), as well as the problem of leading the tractive wheel units of roof segments in the condition of transverse deformations of the dock's hull, should be solved.

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