

# Selected problems of technological preparation of production of a two-segment passenger inland waterways ship of a combined structure

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## ABSTRACT

*This paper presents some aspects of technical preparation of production of inland waterways ship of combined structure contained partly: classical structures (bow and stern part) and sandwich panel structure. Due to prototype character of inland waterways ship structure it was decided to define a new subdivision of shipbuilding process into phases and create new classification principles of constructional and technological documentations.*

**Keywords :** sandwich panels, documentations, phases of production, subdivision, structure

## INTRODUCTION

Main tasks of technical preparation of production of a given product contain elaboration of constructional documentation respective of a given design stage (Preliminary design – PW, Technical design – PT, Working design – PR) (in the frame of constructional preparation of production), and technological documentation (in the frame of technological preparation of production). In the case of ship production the elaboration of constructional and technological documentation is based on the constructional and technological subdivision of sea-going ships covered by the Branch standard ZN- 80/101088 [1] as well as the principles of numbering and nomenclature covered by the Branch standard ZN – 80/101089 : Design & construction documentation of sea-going ships [5].

Approaching to elaboration of the assumptions for the outline technology of production of the inland waterways ship which is designed in the confines of the INCOWATRANS project, one has met several problems resulting from distinctness and novelty of the ship in question. The inland waterways ship is a floating unit composed of two autonomous parts : a pusher and hotel barge. Construction of each of the mentioned parts is combined one, i.e. composed partly of classical structure (bow and stern part) and partly of sandwich panel structure. The panel structure greatly differs from the traditional structure as far as design principles are concerned. As the analyzed inland waterways ship constitutes a floating unit of prototype character for Polish shipbuilding industry, elaboration of the following documents has been deemed justified :

- a) a new subdivision of shipbuilding process into phases (in the frame of technological preparation of production)
- b) classification principles of constructional and technological documentation (in the frame of constructional preparation of production)
- c) proposals of modification of the typical work places used in shipyards in order to adjust them for the purposes of machining and prefabrication of panel structures
- d) assumptions for elaboration of a model workmanship standard for the hull structure consisted of panel elements and transition regions, i.e. connections between panel structure and classical single-plating structure.

This paper presents the assumptions for the outline technology of production of the inland waterways ship, in particular with development of the topics contained in the points a) and b).

In the summary, also other, more detailed, problems associated with the outline technology of production, which go beyond the scope of this paper, are sketched.

## ASSUMPTIONS FOR THE OUTLINE TECHNOLOGY OF PRODUCTION

The outline technology of production of ship is one of the crucial documents prepared in the frame of the plan of preparation and commencement of production of prototype ship, which determines main technological and organizational information necessary for realization of ship production process. The document contains as a rule the following information dealing with :

- \* construction and function (purpose) of a ship : general data (type of ship, ship owner, function, engine room position, ambient conditions etc), technical data (main dimensions, speed, kinds of materials, ship class and institution supervising construction of ship)
- \* site and methods of building the ship (subdivision of ship building process into phases), basic deadlines of building process (the so-called “mile stones” of building schedule, associated with subdivision of ship building process into phases)
- \* technological remarks (concerning subdivision into sections and blocks, prefabrication, general concepts of building particular fragments of ship hull, subdivision into outfitting regions etc)
- \* list of associated documents (in particular list of technological instructions being in force)
- \* the workmanship standard for hull structure.

As above mentioned, the building process of the ship in question is of a prototype and innovative character.

Its novelty consists in wide application of steel sandwich panels. Hull structure of the ship is combined and non-uniform. Its bow and stern parts are traditional (i.e. of a single, transversally-supported plating and traditionally manufactured).

The midship part of cylindrical form, constituting about 65% of ship's length, is designed as a panel structure whose design process and production methods differ substantially from those of traditional construction.

Hence, the necessity results of elaboration of a new subdivision of ship production process into phases and classification principles of constructional and technological documentation in the frame of the outline technology of production of the inland waterways ship.

As far as the subdivision of ship production process into phases is concerned the following reasoning was applied :

- \* irrespective of a building place of an inland waterways ship, its production process will be carried out with taking into account the subdivision of the hull into the fragments of conventional structure and those of panel structure
- \* building method of the ship's hull fragments of panel structure will be realized differently depending on a kind of applied sandwich panels :
  - ♦ Rough steel sandwich panels, i.e. those subjected to initial machining process in a shipyard which builds the ship
  - ♦ CAD steel sandwich panels, i.e. those delivered to the shipyard after machining by their manufacturer in accordance with CAD documentation prepared by and received from the constructional – technological team.

The notions : rough panels and CAD panels have been introduced for the purposes of the INCOWATRANS project; they have not been so far used in the subject-matter literature, where such panels are not distinguished depending on a degree of their prefabrication by manufacturer. The classification principles of constructional and technological documentation were elaborated on the basis of the existing, widely known subdivision established in the Branch standard ZN-80/101088 [1], by adjusting it to the needs of building of a prototype ship. A novelty is the proposal of changing the principles of numbering Classes, Groups and Subgroups as well as the adjustment of items constituting content of particular groups and subgroups to the needs resulting from the specificity of the combined panel – conventional hull structure of the inland waterways ship. The proposed changes of numbering principles should not be considered final ones. They have to serve for putting in order the documentation necessary for building the prototype ship as well as implementing and making use of informatics techniques in the area of documentation management. In the case if a shipyard commences production of similar ships in series it will be necessary to critically review the proposals and possibly to adjust them to the shipyard's possibilities; it especially concerns outfitting phases resulting from application of panels. The proposed classification principles of documentation may be considered as a model reference, which may be justified by the fact that none of the Polish shipyards is today prepared and experienced in building the ships consisted of steel sandwich panels.

### CHARACTERISTICS OF STEEL SANDWICH PANELS

One of the main assumptions for production process of the ship in question is that the sandwich panels - irrespective of their initial state (either rough or CAD machined) - are delivered to the shipyard building the ship in the form of ready product, which means that the shipyard does not manufacture such panels.

The application of sandwich panels to the building of ship results in that :

- \* Range of technological operations realized by the shipyard will depend on a state in which the panels would be delivered
- \* Certain technological operations will be common for both rough and CAD panels, whereas some of them will be characteristic for rough panels only.

### *Characteristics of rough panels*

The rough panels are such sandwich panels which are subjected to initial machining in the shipyard which builds the ship, and they are delivered in accordance with standard gabarites, filling material or without it. Example gabarites of the panels are shown in Fig. 1, [2].

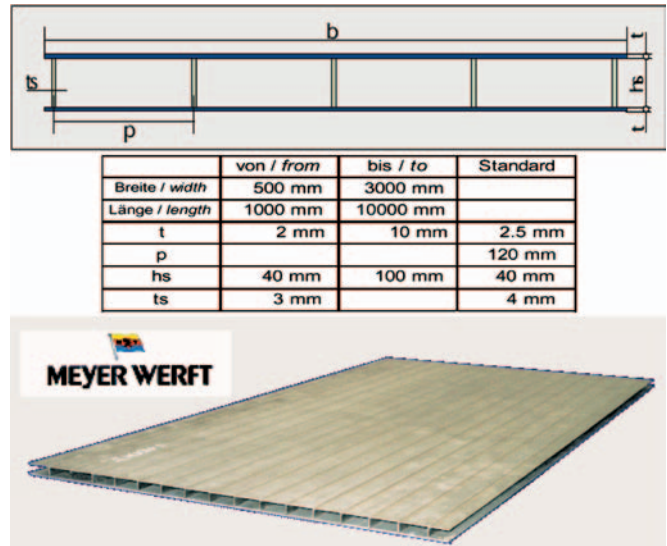


Fig. 1. Example rough panels .

The range of technological operations applicable to rough panels is the following : delivery control according to a technological instruction, storage, transport (of panels and fragments of the structure made of panels, including inter-operational transport), precise cutting, edge preparation to welding, cutting the openings and passages, straightening (locally around cut and to-be-framed openings, free edges in the area of welded joints), welding the panels, assembling and outfitting acc. Phase 08 (Prefabrication of sections, outfitting with : passages and fixtures, seatings, installations), painting and preserving (including the filling of internal space between panel plates, quality control and final acceptance.

### *Characteristics of CAD panels*

The CAD steel sandwich panels are such panels delivered to the shipyard, which are fully machined by the panel manufacturer basing on the achieved CAD documentation prepared by the design - constructional- technological team. Such panels contain some outfit elements, fastening sockets or machinery seatings. An example CAD panel is shown in Fig.2.

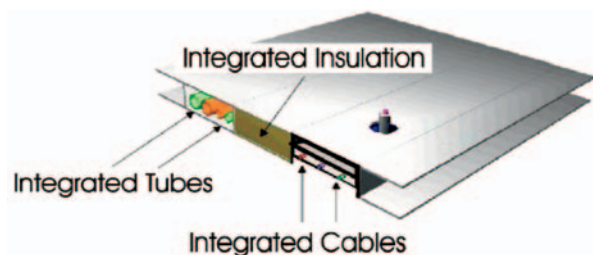


Fig. 2. Example CAD panel equipped with some outfit elements [3] .

As far as CAD panels are concerned the range of technological operations is similar to that for rough panels – and differences deal with : application of margins and technological allowances (certain edges of CAD panels may be prepared ready-to-welding), outfitting acc. Phase 8 dependent on a degree of outfit work made by manufacturer, range of painting and preservation of panel inter-plating volumes.

### ***Subdivision of production process of inland waterways ship into phases***

Building cycle of a ship arising in a shipyard is split into building periods which determine duration time of particular phases of production process, called also the building phases. The usual subdivision of ship building process into phases of : machining, prefabrication, assembling and tests (trials) [4] is rough one, which finds practical application only in the preliminary design of technological processes of ship production. Every shipyard realizing ship building processes applies practically

different phase subdivisions of production process, dependent on its own technological and organizational level, and depending on a degree of minuteness of detail of production process scheduling. The below proposed subdivision of building process of inland waterways ship into phases (Tab.1) is modeled on the phase subdivision which is in practical use of shipyards. It does not mean that the proposed subdivision is the only one. A shipyard which would be ready to undertake building the inland waterways ship may itself apply another phase subdivision of building process according to its own experience and needs. The below given presentation of the proposal of subdivision of building process of inland waterways into phases is aimed at emphasizing the distinctness of building process of panel structure as compared with that of conventional ship structure. The distinctness concerns first of all the building phases beginning from launching and deals with differentiating the tasks specified in the outline scope of work, and with events ending a given phase. The subdivision of building process of inland waterways ship into phases is shown in Tab.1.

*Tab. 1. Subdivision of building process of inland waterways ship into phases*

No. of phase	Conventional part → see the next page			
	Phase name	Unit subdivision	Outline range of work	Events
10	Preparation of documentation	Concept of constructional and technological subdivision of ship into panel-built part and conventional part.	Catalogue of constructional units (joints connecting panels and conventional structures)	Elaboration of documentation together with selection of units
			CAD project	
09	Hull structure machining	Machining groups	Plate initial machining, cutting, initial prefabrication	End of hull machining
08	Prefabrication and outfitting of sections	Hull sections	Prefabrication of hull sections and outfitting with passages and fixtures, seatings, installations	End of prefabrication
07	Assembling and outfitting of blocks	Hull blocks	Assembling of blocks, equipment, passages and fixtures, seatings, mechanisms, outfit modules	Readiness of blocks for butting to panel part
06	Hull assembling and outfitting prior to launching	Outfitting aft and fore regions	Butting and connecting with panel part, joining of installations, preservation prior to launching	Launching
05	Outfitting	Outfitting region: fore + aft + panel part	Mechanisms, devices and installations	End of hull work Readiness to leak proof tests
04	Outfitting to water and gas leak proof tests	Outfitting region: bow + stern+ panel part	Installations, outfit fixtures, sockets, fixtures for ceiling and insulation	
		Tests of compartments and systems	Task regions	Plans and specifications of leak proof tests
03	Final outfitting	Outfitting regions	Small welding operations, insulation, boarding, floor finishing, electric equipment, furniture	Readiness to trials
		Task regions	Painting, fixing spare parts and inventory elements, connecting of electric devices to network	
02	Trials	Task regions	According to program of trials	
01	Finishing work	Task regions	Recommendations from trials. Final outfitting and painting	
00	Hoisting a flag			Delivery of ship

*Tab. 1. Page .... ◀ Subdivision of building process of inland waterways ship into phases .*

Panel part – „rough”					Panel part – CAD			
No. of phase	Phase name	Unit subdivision	Outline range of work	Events	Phase name	Unit subdivision	Outline range of work	Events
10	Preparation of documentation	Concept of constructional and technological subdivision of ship into panel-built part and conventional part.	Catalogue of constructional units (joints connecting panels)	Elaboration of documentation including selection of units	Preparation of documentation	Concept of constructional and technological subdivision of ship into panel built and conventional part.	Catalogue of constructional units (joints connecting panels)	Elaboration of documentation including selection of units
			CAD project				CAD project	
09	Machining of rough panels	Machining groups	Initial machining of plates, cutting, initial prefabrication	End of e. g. machining of hull parts	Machining of panels for assembling and welding	Panels	Cleaning, accurate cutting, cutting of e.g. openings	End of machining of panels
08	Prefabrication and outfitting of sections	2D panel sections	Prefabrication of sections and outfitting with: passages and fixtures, seatings, installations	End of prefabrication	Prefabrication and outfitting of panels	2D panel sections	Joining of panels into flat sections. Assembling of passages, fixtures etc.	End of prefabrication
07	Assembling and outfitting of blocks	3D panel blocks	Assembling of blocks, and equipment, passages and fixtures, seatings, mechanisms, outfit modules	Readiness of blocks to butting with panel part	Joining of flat sections into blocks	3D panel blocks	Joining of “D sections into blocks. Assembling of passages, fixtures etc., seatings and installations.	Readiness of blocks to butting

### CLASSIFICATION OF CONSTRUCTIONAL AND TECHNOLOGICAL DOCUMENTATION AND ITS PRINCIPLES

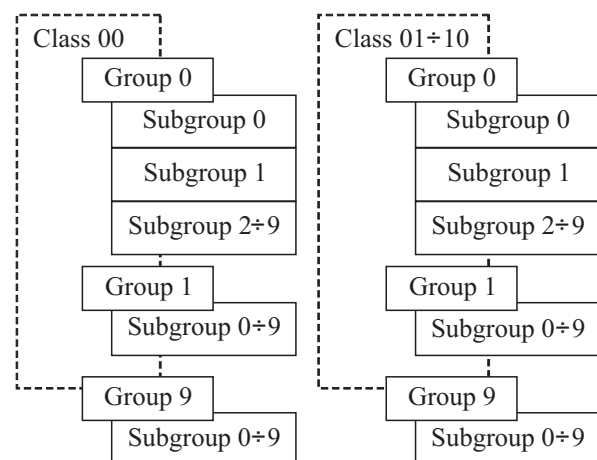
Topical subdivision of constructional and technological problems into classes, groups and subgroups constitutes the subject of classification concerning the building of inland waterways ship.

The following principles of indexing (numbering) the documentation were assumed :

- ✱ Class – two-digit numbers – from 00 to 10
- ✱ Group – Class number + one digit – from 00 to 10 + (0 to 9)
- ✱ Subgroup – Class number + Group number + one digit – from 00 to 10 + (0 to 9) + (0 to 9)
- ✱ After Subgroup number, the symbol „ - ” or „ / ” has to be included.

If necessity of further subdividing arises subsequent subdivision layers have to be numbered with two digits and separated by the symbols put after subgroup number. Application of successive layers is associated with a degree of minuteness of detail of documents. It should be aimed at attaching infor-

mation (number of document) on mutually related documents, non-depending on their hierarchy in structure.



*Fig. 3. Numbering principles of subdivision into classes, groups and subgroups .*

In Tab.2 the subdivision into classes and groups is presented. The most important changes after the modification are as

*Tab.2. Constructional and technological classes and groups of inland waterways ship .*

Class 00 Theoretical documentation	Class 01 Hull	Class 02 Deck equipment	Class 03 Accommodation outfit	Class 04 Engine room (ER)	Class 05 Piping	Class 06 Electrical equipment and automation	Class 07 Special arrangements	Class 08 Other elements	Class 09 Inventory and spare parts	Class 10 Technological subdivision
0 General group	0 General group	0 General group	0 General group	0 General group	0 General group	0 General group	0 General group	0 General group	0 General group	0 General group
1 Hull form, spatial layout	1 Bottom structures	1 Steering and manoeuvring equipment	1 Insulation and boarding of living, sanitary and service accommodations and corridors	1 Shafting	1 ER piping	1 Power installations and switching devices	1	1	1 Standard inventory elements	1 Lofting
2 Hydrodynamics and model tests	2 Bulkheads and partitions	2 Loading equipment	2 Insulation and boarding within ER	2 Main propulsion	2 Bilge, ballast and fuel piping	2 Lighting installations	2	2	2 Standard spare parts	2 Positioning and shifting the ship
3 Masses and their centres	3 Side structures	3 Anchoring, mooring and towing equipment	3 Coverings of floors and walls	3 Exhaust gas piping	3 Hull piping	3 Signalling installation	3	3	3 Additional inventory elements	3 Scaffolding communication and transport
4 Hydrostatics and stability	4 Decks	4 Floating life- saving, rescue and working appliances	4 Doors, windows and sleeves connecting the ship segments	4 Electric generating sets	4 Driving installations for devices outside ER	4 Telecommunication installations	4	4	4 Additional spare parts	4 Electrical installations
5 Strength, vibrations and noise	5 Stern structures	5 Outer communication devices	5 Equipment of living, sanitary and service accommodations	5 Mechanisms and devices	5 Fire - extinguishing installations	5 Radio- communication and navigation installations	5	5	5 Positioning and arranging of inventory elements	5 Gas & water installations
6 Application of materials	6 Bow structures	6 Hold closing equipment	6 Equipment of compartments for refrigerated and non- refrigerated provisions	6 Compartments	6 Ventilation and air- conditioning installations	6 Installations of other devices	6	6	6 Positioning and arranging of spare parts	6 Heating and ventilating
7 Constructional and technological agreements	7 Superstructures and deck houses	7 Closing equipment of openings together with companionways	7 Equipment of general stores and workshops beyond ER	7	7 Central heating and sanitary installations	7 Automation	7 Pump room	7	7	7 Conservation and preservation of ship during building
8 Trials and tests of ships	8 Various hull elements	8 Various deck equipment	8	8 Floors and gratings in ER	8 Potable water	8 Cableways, arrangement and fixing of devices	8	8	8	8 Tests, trials and overhauls
9 Calculations and economical analysis, contracts	9 Hull passages, fixtures etc	9 Coverings of outer decks	9 Protecting coatings	9 Lifting equipment, steering and various elements	9 Other piping and installations	9 Cables and wires	9 Manoeuvring and stabilizing devices	9	9	9 Technological documentation non-involving costs

follows : the renumbering of the technological Class-00 into Class-10; the non-filled positions of groups and subgroups of the classes in which they appear constitute a reserve for additional subdivisions. Details of the subdivision together with the blank for particular problem's executors can be found in [6].

### GENERAL COMMENTS

The above presented problems do not exhaust the entire scope of the topics of the outline production technology of inland waterways ship and the associated technological documentation. The following items should be developed in detail :

- selection of building site and methods
- determination of detail subdivision of panel part of ship hull into sections and blocks in a chosen shipyard (depending on its technological conditions and kind of applied panels)
- determination of a range of machining and prefabrication of panels
- determination of an assembling method of whole panel block
- technological guidelines for preparation of panel structure to preservation and filling
- elaboration of comprehensive technological instructions such as : plan of measurement reference bases and plan of surplus values and allowances, determination of a scope of special instrumentation, outline hull manufacturing tolerances
- catalogue of standard structural joints

- catalogue of ship equipment - with taking into account EU directives, requirements of ship owner and TK, as well as technological level of a chosen shipyard.

Moreover, each of the above mentioned problems should be assigned a relevant document such as : instruction, plan, list (documents of acceptance, protocols, certificates etc.). The numbering of the documents should be in compliance with the classification principles of constructional and technological documentation. They will be elaborated as separate tasks realized within the frame of the project in question.

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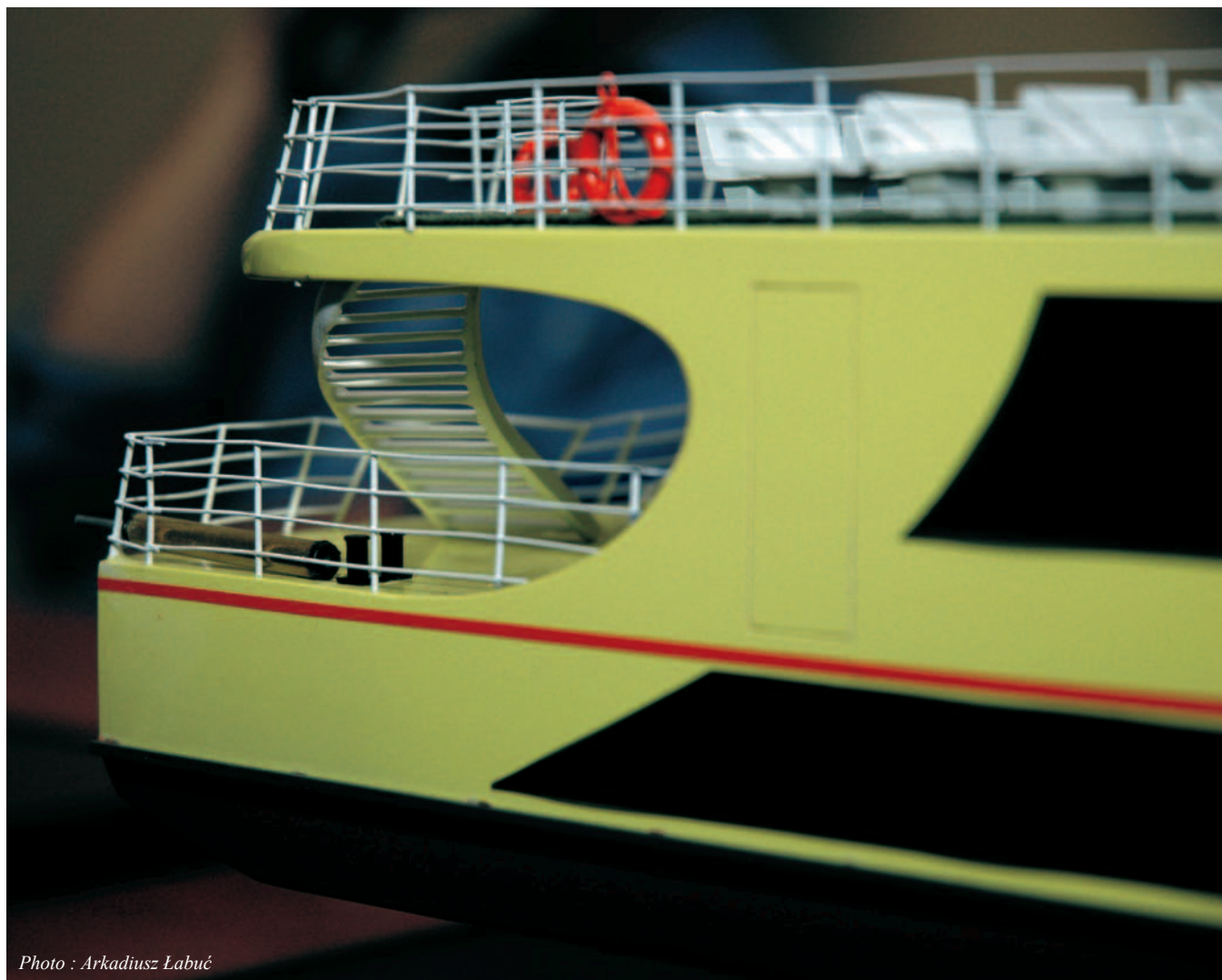


Photo : Arkadiusz Łabuć