

# Anchoring and mooring equipment for a two-segment inland waterways ship

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## ABSTRACT

*This paper presents a review and analysis of anchoring and mooring equipment for contemporary inland waterways ships. Also, a design proposal of such equipment for a two-segment passenger ship as well as a list of selected components of the equipment and plan of their arrangement on the ship's deck, is presented.*

**Keywords :** inland waterways ships, shipboard equipment, anchoring and mooring equipment

## INTRODUCTION

Anchoring and mooring equipment of inland waterways ships is one of the crucial elements of shipboard equipment of such ships. As opposed to anchoring equipment of sea-going ships where ship is fitted as a rule with two bow anchors, inland waterways ships should be equipped – in compliance with PRS rule requirements [3] – with four anchoring units : two on the bow and two on the stern.

In this paper is presented comparative analysis of the anchoring and mooring equipment for two-segment passenger inland waterways ship, selected on the basis of PRS rules and compared with the equipment applied on contemporary inland waterways ships operating on Polish waterways. The analysis was elaborated on the basis of photographs taken by these authors, as well as relevant information available by internet. On the basis of the analysis, new solutions of anchoring and mooring equipment were elaborated and proposed for the ship in question designed by the team of Faculty of Ocean Engineering and Ship Technology, Gdańsk University of Technology.

The main design parameters of the two-segment ship composed of a pusher and hotel barge, are as follows :

★ length of each segment	$L = 56 \text{ m}$
★ breadth	$B = 9 \text{ m}$
★ draught	$T = 1 \text{ m}$
★ mass displacement:	
for $T = 1 \text{ m}$	$D_{1,0} = 440 \text{ t}$
for $T = 1.2 \text{ m}$	$D_{1,2} = 530 \text{ t}$
★ effective output power for ship propulsion	$P = 300 \text{ kW}$
★ contract speed of the entire push-train	$v = 15 \text{ km/h}$

## ANCHORING AND MOORING EQUIPMENT SELECTED ON THE BASIS OF PRS RULES

### Outline of design assumptions

In selecting the anchoring and mooring equipment for the push-train composed of the barge (hotel segment) and the pusher (propulsion segment) one should proceed in the same way as in the case of the classical barge-pusher train. In such case according to the rules it is required to locate anchoring equipment

on the bow of the barge as well as on the stern of the pusher. Then, for the two units joined together only one Equipment Number is calculated and on its basis main data concerning the anchoring and mooring equipment are determined.

However, it should be taken into account that for the hotel segment also such service periods are provided for when it lies along quay and the pusher (also fitted with tourist equipment) sets out on an independent tourist trip. Hence it is necessary to fit the pusher with anchoring and mooring equipment also on the bow. Its elements should be selected on the basis of Equipment Number calculated for the pusher only. As a result, their gabarites and weight will be accordingly smaller than those determined for the entire push-train.

### Equipment Number

Calculation of the Equipment Number was preformed on the basis of the above formulated assumptions and in compliance with the “Rules for the classification and construction of inland waterways ships” of Polish Register of Shipping [3], which yielded the following values :

$N_{az} = 1155 \text{ m}^2$  – for two joined segments of ship (push-train)

$N_{ap} = 770 \text{ m}^2$  – for the pusher alone.

### Selection of anchoring and mooring equipment

For the above given values of Equipment Number, below are presented the main parameters of anchoring and mooring equipment for both ship segments, determined on the basis of the PRS Rules, (detail calculations and description of particular elements of the equipment can be found in [2]).

#### The pusher

##### Anchoring equipment :

###### Bow :

- ❖ 2 anchors of 325 kg mass each
- ❖ chain diameter – 15 mm (steel grade 2)
- ❖ anchor chain length – 65 m (two pieces)
- ❖ anchor windlass (capstan) towing force ~7 kN (steel grade 2)

*Stern :*

- ⇒ 2 anchors of 432 kg mass each
- ⇒ chain diameter – 16 mm (steel grade 2)
- ⇒ anchor chain length – 42 m (two pieces)
- ⇒ anchor windlass (capstan) towing force ~8.5 kN (steel grade 2)

*Mooring equipment :*

- ⇒ number of ropes – 2
- ⇒ length of one rope – 99 m
- ⇒ breaking strength – 184.8 kN (wire ropes); 230.5 kN (synthetic fibre ropes)
- ⇒ rope selection – material: PP (polipropylene), breaking strength: 264.97 kN, diameter: 44 mm, mass: 0.88 kg/m, producer : Lanex
- ⇒ bollards (2 fore and 2 aft) of the following parameters : D – 132 mm, L – 444 mm
- ⇒ hawse-pipes and fairleads – 2 fore and 2 aft
- ⇒ mooring winches (capstans): aft : mooring heads of anchor windlasses [towing force ~8.5 kN (steel grade 2)], fore : mooring heads of anchor windlasses [towing force ~7 kN (steel grade 2)].

**The barge**

*Anchoring equipment :*

*Bow :*

- 2 bow anchors of 450 kg mass each
- chain diameter – 17,5 mm (steel grade 2)
- anchor chain length – 65 m (two pieces)
- anchor windlass (capstan) towing force ~9,6 kN (steel grade 2)

*Mooring equipment :*

- number of ropes – 2
- length of one rope – 99 m
- breaking strength – 184.8 kN (wire ropes); 230.5 kN (synthetic fibre ropes)
- rope selection – material: PP (polipropylene), breaking strength: 264.97 kN, diameter: 44 mm, mass: 0.88 kg/m, producer : Lanex
- bollards (2 fore and 2 aft) of the following parameters: D – 135 mm, L – 450 mm
- hawse-pipes and fairleads – 2 fore and 2 aft
- mooring winches (capstans): fore : mooring heads of anchor windlasses [towing force ~11.5 kN (steel grade 1); ~9.6 kN (steel grade 2)], aft : one additional mooring capstan of ~3 kN towing force.

## ANALYSIS OF ANCHORING AND MOORING EQUIPMENT INSTALLED ON SIMILAR CONTEMPORARY SHIPS

The analysis of anchoring equipment of similar contemporary ships was performed on the basis of available data concerning inland waterways ships sailing mainly on European waterways, including the modern tourist ship „Frederic Chopin” which has lately made trips along the Lower Vistula.

The example photographs of partly visible elements of the anchoring and mooring equipment, and of their arrangement on the deck are shown in Fig. 1, 2 and 3.

As a result of the performed analysis of the equipment in question a few important regularities have been stated, namely :

1. All the analyzed ships are fitted with patent anchors of higher holding power.

2. All of them are equipped with only one anchor aft.
3. The anchoring and mooring devices applied on them constitute winches with horizontal rotation axis of working elements, i.e. rope drums and heads as well as chain wheels.
4. In the bow part of ships anchor chains are used whereas in their stern part such role is fulfilled by wire ropes.
5. Mooring bollards in the bow part of ships are usually arranged in a triple mode, and placed along ship's side just near its edge.



Fig.1. Anchoring and mooring equipment arranged in the bow and stern part of the tourist ship „Frederic Chopin”.

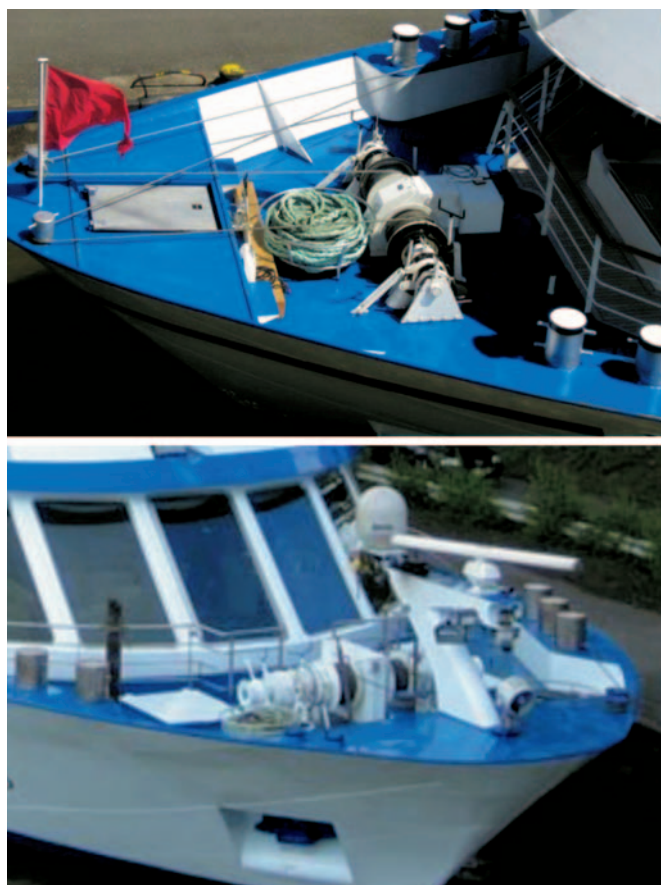
### Comments

**Ad. 1.** The application of patent anchors of higher holding power on inland waterways ships is fully justified. As a rule the ships are rather small and their owners tend to make full use of their capacity and deadweight. As compared with Hall's anchors commonly applied on sea-going ships, the patent anchors of higher holding power make it possible to reduce anchor mass down to 75% of the anchor mass given in the relevant PRS rules for sea-going ships, maintaining the same holding power at least. Application of the anchor with higher holding power is as a rule associated with the use of higher strength anchor chains, and – owing to this – of smaller diameter and mass, which makes it possible to lower size and mass of anchor windlasses as well as other units of anchoring equipment. It is specially important in the case of small passenger ships intended for sailing in shallow waters.

**Ad. 2.** The application of only one anchor aft, but having a higher holding power, results mainly from a limited deck area in that part of ship. The aft deck, usually having relatively small area, must accommodate also other elements of shipboard equipment, such as e.g. life saving appliances which require an appropriate free space to ensure safe evacuation. For this



reason one presently tends to replace two „sets” of anchoring and mooring equipment with one, but more versatile and modular. It brings additional measurable advantages resulting from a smaller weight of that part of ship which is as a rule heavily loaded by ship's power plant located under the deck.



*Fig.2. The anchoring and mooring equipment arranged in the bow part of the ship .*

**Ad. 3.** According to the above given comments, the winches, as opposed to capstans, are more versatile machines which can realize more functions. The winch can be consisted of three mooring-anchoring units simultaneously: rope drum, mooring head and chain wheel. If the anchoring-mooring winches are appropriately located on the deck all necessary operations can be performed and some deck area, mass and cost of the device can be simultaneously saved.

**Ad. 4.** Space in the bow part of ship is as a rule less valuable for equipment arranging, hence there is no problem with location of small chain lockers. The fact and advantageous features of the chain tension members make application of anchor chains on the bow, justified. To arrange an appropriate space in the stern part of ship, either on or under the deck, is usually very difficult as just there ship's power plant is located, and various cable and pipe lines or ballast tanks are placed. For this reason, application of a wire rope with only short section of chain near the anchor, instead of anchor chain, is more advantageous, as the rope can be stored on the winch drum and the winch having modular structure does not require any additional space under the deck, as opposed to capstans.

**Ad. 5.** Bow decks are usually open ones hence especially on passenger ships it is important to arrange particular elements of mooring equipment in a way as favourable as possible. The location of bollards just near the ship side makes it possible to eliminate either hawse-pipes or fairleads and this way to extend free area of that part of the deck.



*Fig.3. Examples of the anchoring and mooring equipment arranged in the stern part of various inland waterways ships .*

## PROPOSED ANCHORING AND MOORING EQUIPMENT

To elaborate the design of anchoring and mooring equipment for the pusher-barge train it is necessary to take into account not only the requirements of classification societies but also development trends and novel technical solutions. In the authors' opinion as the PRS rules for inland waterways ships, still being in force, were published in the 1980s, they should be considered applicable in a rather not obligatory way so as not to constrain progress in developing the equipment in question.

The above presented example solutions of the equipment in question applied on the new ships operating in European waters show that other classification societies have already approved the mentioned development trends. With taking this into account, the following design proposal of anchoring and mooring equipment for the designed ship, are presented below :

### The pusher Anchoring equipment :

Bow :

- ➔ 2 higher holding power anchors of 245 kg mass each
- ➔ chain diameter – 11 mm (steel grade 2)
- ➔ anchor chain length – 65 m (two pieces)
- ➔ anchor windlass towing force ~4 kN (steel grade 2)

Stern :

- ⇒ 1 higher holding force anchor of ~500 kg mass
- ⇒ wire rope (instead of a chain) of 116 kN breaking strength
- ⇒ anchor rope length – 55 m (plus 1 m of chain section)
- ⇒ anchor windlass towing force ~7 kN

### Mooring equipment :

- ➔ number of ropes – 2
- ➔ length of one rope – 99 m
- ➔ breaking strength – 184.8 kN (wire ropes); 230.5 kN (synthetic fibre ropes)
- ➔ rope selection – material: PP (polipropylene), breaking strength: 264.97 kN, diameter: 44 mm, mass: 0.88 kg/m, producer : Lanex
- ➔ bollards (2 fore and 2 aft) of the following parameters: fore : D – 300 mm, L – 590 mm (with guide roll), aft : D – 135 mm, L – 450 mm
- ➔ hawse-pipes and fairleads – 2 aft
- ➔ mooring winches (capstans): aft : mooring heads of anchor windlasses [towing force ~7 kN (steel grade 2)], fore : mooring heads of anchor windlasses [towing force ~4 kN (steel grade 2)].

### The barge Anchoring equipment :

Bow :

- ⇒ 2 higher holding power anchors of 340 kg mass each
- ⇒ chain diameter – 15 mm (steel grade 2)
- ⇒ anchor chain length – 65 m (2 pieces)
- ⇒ anchor windlass towing force ~7 kN (steel grade 2)

### Mooring equipment :

- ⇒ number of ropes – 2
- ⇒ length of one rope – 99 m
- ⇒ breaking strength – 184.8 kN (wire ropes); 230.5 kN (synthetic fibre ropes)
- ⇒ rope selection – material: PP (polipropylene), breaking strength: 264.97 kN, diameter: 44 mm, mass: 0.88 kg/m, producer : Lanex
- ⇒ bollards (2 fore and 2 aft) of the following parameters: fore : D – 300 mm, L – 590 mm (with guide roll), aft : D – 135 mm, L – 450 mm
- ⇒ hawse-pipes and fairleads – 2 aft
- ⇒ mooring winches (capstans): fore : mooring heads of anchor windlasses (towing force ~7 kN (steel grade 1)); aft : one additional mooring capstan of ~3 kN towing force.

The proposed anchoring and mooring equipment for the pusher is shown in Fig.4. On the bow, in parallel to the ship's axis of symmetry, is located the twin bollard (a guide roll is fixed on one of them, which allows the mooring rope to go onto winch perpendicularly) as well as the anchoring-mooring

winch. The winch is fitted with the mooring drum which serves also for rope storage, chain wheel, as well as mooring head. The winch obliquely is situated to the ship's axis of symmetry. The same set of the equipment is provided for on the other side of the ship.

The winch on the stern is also an anchoring-mooring winch in which, instead of chain wheel, the drum is fitted to reel the anchor rope on (instead of a chain). Additionally, the winch is fitted with the mooring head. The mooring rope is directed onto the head by means of the fairleads and guide roll. Along course of the mooring rope two mooring bollards are placed just near the ship sides, situated perpendicularly to the ship's axis of symmetry.

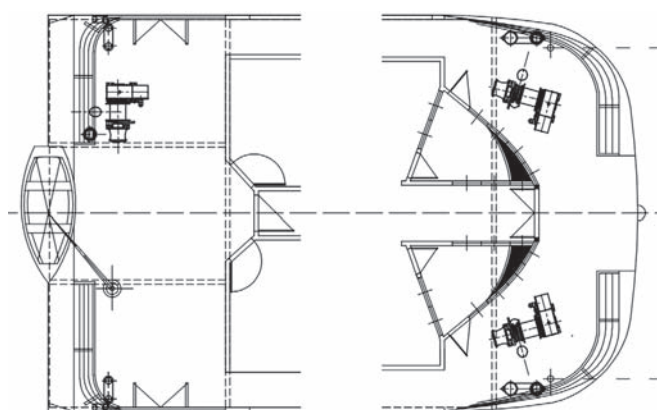


Fig.4. Example arrangement of the anchoring and mooring equipment on the pusher .

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