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SELECTED PROBLEMS OF SHIP SAFETY IN THE PROCESS OF DOCKING

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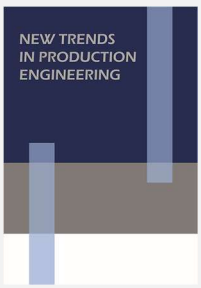

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Abstract. This article concerns safety during ship docking operations. It presents its specificity for this type of operation, describes selected problems that may occur during its operation and identifies the main factors initiating extraordinary situations. The article presents 4 examples of accidents during docking operations in recent years. Cause and effect analysis was carried out and presented graphically. This analysis illustrated the occurring errors in the safety system during the docking operation.

Keywords: ship's docking, safety, accidents, threats

INTRODUCTION

Docking is a kind of activity necessary in the ship's operation process, which has a direct impact on keeping it in proper technical condition. However, this operation may be dangerous and is characterized by a high level of risk occurrence. This is due to the improper preparation of ships for docking as well as errors committed during the operation itself.

Solving problems related to ensuring safety during docking of ships requires determining and observing appropriate procedures related to organizational and technical safety management. It is important to identify and systematize the threats occurring during the docking operation, which will allow for the selection of effective methods of counteracting them.

Floating docks or dry docks are necessary equipment for the shipyard, both in Poland and in the world in which ship construction, repair and maintenance are carried out. There are many incidents and accidents during ship's docking and works on the dock, which is why further improvement of the level of security requires detailed analysis and conclusions from emerging emergency situations.

The aim of the article is a cause – effect analysis of selected ship accidents during docking operations. This analysis was carried out on the example of four accidents that took place in recent years.

TYPES OF DOCKS AND THEIR LOCATION

Docks as hydro technical naval buildings serve to keep ships in a given position without the participation of liquid in which they could be submerged. The most common method is the use of **dry docks**, i.e. basins with sealed gates, to which the vessel enters, and then water is pumped out, and **floating docks** carrying the vessels entirely above the water surface.

According to Det Norske Veritas (DNV) definition „*a floating dock is a type of pontoon for dry docking vessels, possessing floodable buoyancy chambers and a "U" shaped cross-section to lift a vessel out of the water*". Floating docks are divided into the following types:

- „*Caisson type: dock in which the bottom pontoon and both dock wings are continuous and inseparable.*

- *Pontoon type: dock in which the dock wings are continuous and the bottom consists of individual noncontiguous pontoons. The pontoons are permanently or detachably connected to the dock wings*" (Rules for Classification of Floating Docks, 2012).

According to the American Bureau of Shipping (ABS), the following types of floating docks can be selected:

- „*One piece dry dock type in which the wing walls and the pontoon are continuous and inseparable along the dock structure*
- *Continuous-wing, sectional-pontoon type in which the wing walls run continuously and the bottom is formed of separable or permanently attached sectional pontoons*
- *Continuous pontoons and discontinuous wing walls.*
- *Sectional type with discontinuous sections of the wing walls and the bottom pontoon in which rotation or vertical movement or both is possible between each discontinuous section"* (Rules for building and classing steel floating dry docks, 2009).

Due to the fact that many technical problems related to both the construction of the dock and docking operations have not been solved to this day, there is a need for continuous improvement of these systems. In (Dymarski, 2005) there are presented alternative design concepts and their comparative analysis of ship docking systems for a floating dock. An analysis of floatability and stability of the floating dock- docked ship system was discussed in (Stasiak, 2005). Accessible systems for augmentation the docking and harbor navigation are analyzed in (Felski et al, 2014).

Location of docks is conditioned by a number of factors to which we can include sufficient depth of water to allow access from the water side, so as to allow docking the ships with the required draft including shipping conditions. The location next to the shipyards or ports provides suitable dock facilities on land e.g. warehouses, access roads, or workshops.

Both dry and floating docks are found in countries where the shipbuilding industry is strongly developed. The largest dry dock in the world is in Japan at the Koyagi shipyard (990 m long), while in Europe – in France at the STX shipyard from Saint-Nazaire.

Among the countries that have this type of construction we can mention for example China, Singapore, Taiwan, Vietnam, South Korea, South Africa, Brazil, USA, United Arab Emirates, Philippines, Panama, Canada, and from European countries Belgium, Denmark, Germany, Finland, Holland, Italy, Malta, Portugal, Romania, Spain or the United Kingdom.

In Poland, dry docks are located in Gdynia Shipyard. They have a length of 241 and 380 m. The largest floating dock in Poland is in the Marine Repair Shipyard Gryfia, it is over 200 meters long and can lift ships with a capacity of up to 40,000 DWT.

The largest floating docks in the world can include over 400 meters of constructions, which are located in shipyards in South Korea (Samsung Heavy Industries), China (CIC-Shipyards) and the Netherlands (Keppel Verolme).

CHARACTERISTICS OF THREATS AND TYPES OF EVENTS OCCURRING DURING SHIP DOCKING

Taking into account the source of initiating factors, the following types of threats occur in ship docking operations:

- Technical – they can be determined by the reliability of devices and machines used for work and the significance of undesired events of each of the elements of mechanisms, equipment and construction. These may be main engine failures, voltage decay, predictable or unpredictable problems with lifts and/or capstans and with dock pumps. There are construction, production and operational risks. Threats may arise, for example, from the defects of materials used during ship docking maneuvers, e.g. excessive consumption of cum may result in their breaking.
- Maintenance – are determined by external and internal factors. They are related to such works as preparing a ship for docking, preparing a dry dock for receiving a ship, immersing an empty floating dock, introducing a ship to the dock, emerging a dock with a ship, and the stage of undocking the ship.

- Hydro meteorological conditions – strong wind, waves, currents or tides affect the correctness of ship docking and undocking operations, they may hinder maneuvers. Night time, dense fog, rain or snow limit visibility, make it difficult to communicate properly via portable radios.
- Human errors – most accidents and breakdowns are caused by human errors. Threats result from the ignorance of the procedures and the applicable regulations by the dock staff and the ship's crew. The main causes of threats include: lack of proper communication, improper division of duties into individual people, lack of proper preparation and planning by persons, omission and non-compliance with health and safety rules.

These threats can occur during all stages of docking ships. They can cause different types of events and generate irreversible effects, examples of which are shown in Figure 1.

Fig. 1. Types of threats and their possible consequences.

Source: own study

ANALYSIS OF SELECTED ACCIDENTS DURING DOCKING OF THE SHIPS

Compliance with safety standards in such a difficult work environment which is the shipyard seems to be obvious. However, despite the measures and procedures to this day has not eliminated all the risks associated with the docking of ships.

The analysis of selected accidents that occurred during docking will be presented below. One of them took place at Vigor Industrial Shipyard in Washington, while the next three took place in Poland.

Among shown in Table 1 accidents, most of them were caused by human error and technical failures. In these accidents, both the repaired ships and elements of the shipyard infrastructure were damaged. There was also a risk of contamination of the aquatic environment. The result of each of them was financial losses. Figures 2, 3, 4 and 5 show diagrams for the development of events of the accidents analyzed.

The accidents occurring during ship docking indicate both the failure of the technical solutions applied to them as well as the frequent occurrence of human error. The human factor is invariably a weak link in safety systems. It may be the first factor initiating undesirable events. In many cases, it is not a direct source of danger, but its incorrect actions intensify the dangerous development of events, which can have tragic and irreversible consequences. Especially in the case of port maneuvers, the impact of the human factor on safety is particularly important due to the limited maneuvering space. This issue has been discussed in the publication (Hejmlich, 2014).

Accidents involving transverse bending failures of dry dock pontoons were discussed in publication (Heger, 2003) The reason of mentioned accidents was for example: calculation errors of permissible loads on keel blocks or nonacceptable amount of corrosion.

Ecological hazards and a concept of conversion of the existing dock to the ecological class CLEAN was presented in (Rosochowicz & Łącki, 2005).

Table 1.
Examples of accidents during docking operations in recent years

No.	Type and location of the event	Date and place	Description of the situation
1	Dockside capsizing and sinking of towing vessel *Invader* and dry dock.	March 18, 2012 Vigor Industrial Shipyard, Port of Everett, Washington	The uninspected towing vessel Invader capsized after the floating dry dock on which the vessel was positioned flooded and began listing. Both the Invader and dry dock initially sank, but were later refloated.
2	Overturn and partial sinking of the floating dock No. 1 together with the *Hordafor V* chemical tanker	April 27, 2017 *Nauta* Repair Shipyard in Gdynia	Floating dock nr. 1, to which *Hordafor V* was introduced, inclined and sank. The repaired chemical tanker fell over with the dock and partially sank.
3	Damaging the ship hull *M/V Green Egersund* and fuel spill	August 27, 2015 Naval Shipyard in Gdynia	During a ship's docking operation using three tug boats, as a result of pushing the starboard side through one of the tugs, it moved to the right edge of the dock and the staggered part of the stern hit the edge of the mooring roll of the right dock tower. The hull plating was damaged at the level of the heavy fuel tank. Fuel leaked into the port basin.
4	Damaging the plating and fire in the engine room during the operation of undocking of the passenger-car ferry *Princess Benedikte*	March 11, 2015 Gdansk Ship Repair Yard	During the undocking operation, due to the power failure, there was a slight heel to the left side. The ship with its left side leaned against the dock's tower. Water got into one of the rooms. The aggregates were flooded, there was an electrical short circuit, an explosion of batteries and a small fire in the engine room.

Source: own study based on: (National Transportation Safety Board, 2012), (Państwowa Komisja Badania Wypadków Morskich, 2017), (http://www.gospodarkamorska.pl/)

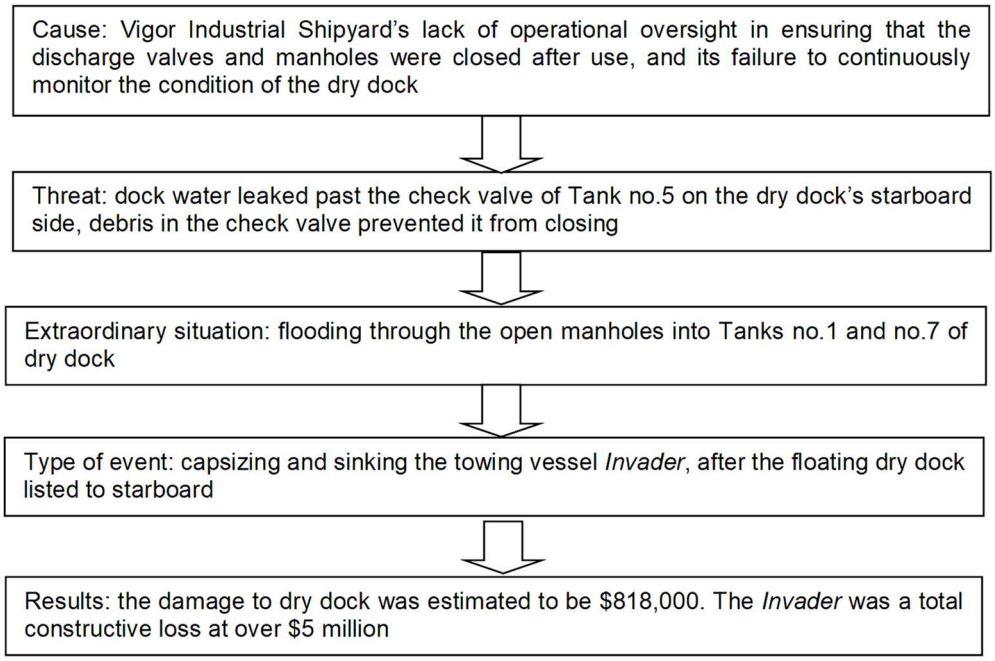

Fig. 2. Diagram of the development of events during dockside capsizing and sinking of towing vessel *Invader*.

Source: own study based on (National Transportation Safety Board, 2012),

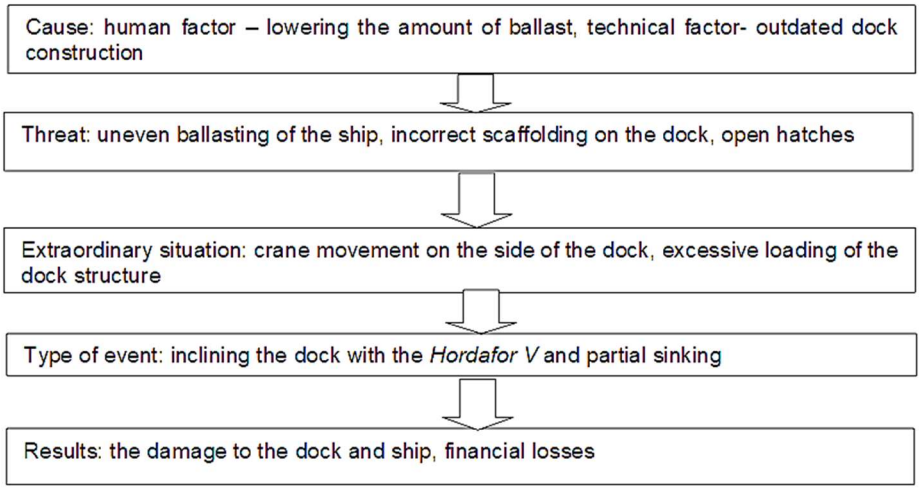

Fig. 3. Diagram of the development of events during sinking of the floating dock No. 1 together with the *Hordafor V* chemical tanker.

Source: own study based on (http://www.gospodarkamorska.pl/)

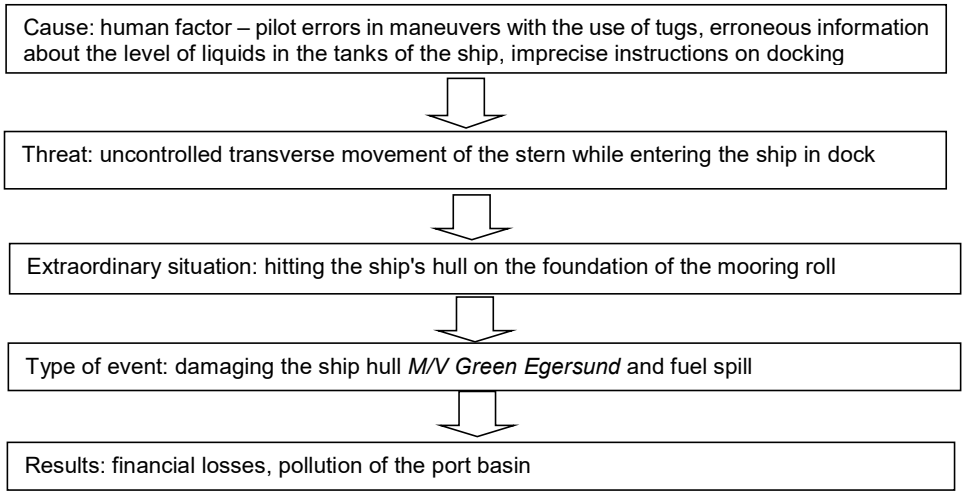

Fig. 4. Diagram of the development of events during damaging the ship hull *M/V Green Egersund*.

Source: own study based on (Państwowa Komisja Badania Wypadków Morskich, 2017)

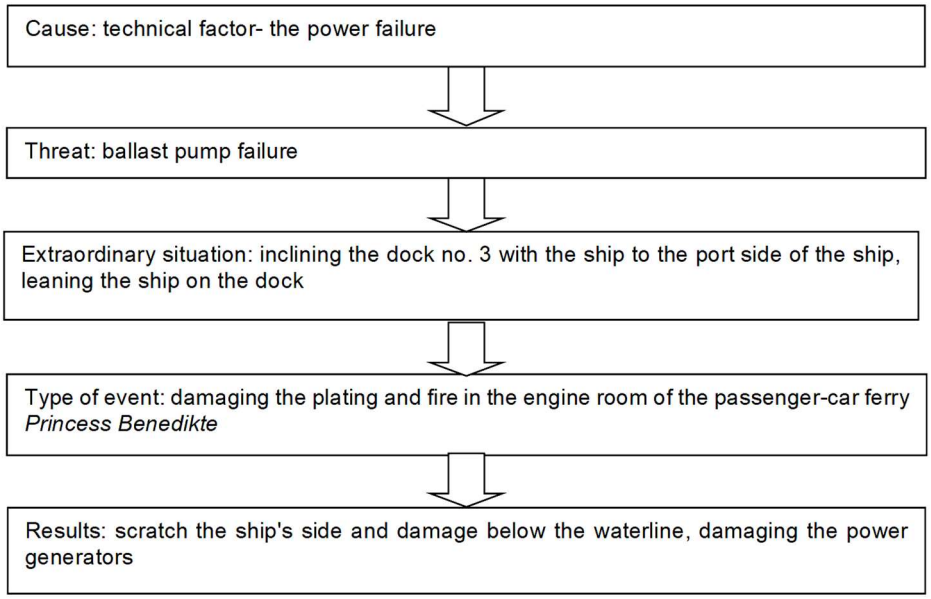

Fig. 5. Diagram of the development of events during damaging the plating and fire in the engine room of the passenger-car ferry *Princess Benedikte.*

Source: own study based on (http://www.gospodarkamorska.pl/)

PREVENTION OF ACCIDENTS DURING DOCKING

In order to increase the level of security during the docking operation, it is important to analyze the existing types of events in order to eliminate certain causative factors or generate appropriate methods of safety management during the occurrence and duration of an emergency situation. Ecological and economic considerations are also important.

Actions to minimize the risk of dangerous events are listed below:

1. Familiarize the dock staff and ship's crew with the procedures and regulations.
2. Analysis and discussion of the fire protection plan in terms of the work carried out.
3. Discussion of emergency actions, determining the method of communication and separating responsibilities for individual people,
4. Organization of meetings regarding security and granting individual permits for particular types of work (e.g. work at heights, work in confined spaces, hot works).
5. Providing personal protective equipment and proper marking of workstations.
6. Every time checking the workstations in terms of safety, e.g. removing / protecting elements that could pose a threat.
7. Checking completeness and readiness to use security measures and fire protection equipment.
8. Docking the ship with the minimum amount of fuel.
9. Conducting inspections and surveys in a timely manner in order to avoid unforeseen problems resulting from technical failures.
10. Monitoring of atmospheric conditions.

Appropriate knowledge and experience of both, crew members and dock staff, combined with compliance with the developed procedures can significantly reduce the risk of accidents during docking.

CONCLUSION

With the development of shipping there is a need for repair works of the fleet of vessels, including works that must be carried out with using of floating or dry docks. Such a situation usually causes an increase in the number of accidents during operations so it is important to ensure an adequate level of safety. The following are of great importance:

- technical condition of docks,
- technical condition of repaired ships,
- proper organization, supervision and control of the docking operations.

The analysis carried out in the article shows that the level of safety during docking operations can be described as rather good. However, there are situations that could have been avoided while maintaining certain requirements and procedures.

The analysis again confirms the greatest impact of the human factor on the cause and course of the accident during the docking operation. In the event of crew members and dock staff failing to fulfill their duties, all employees, the repaired ship and the environment are exposed to the danger.

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