

TECHNOSPHERE SAFETY



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Situation with Fires and the Effectiveness of Fire Alarm Systems at Shipping Facilities

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Introduction. Shipping, as one of the infrastructural transport communications, is a strategic branch of the economy of the Russian Federation. The timely delivery of goods, equipment, materials and raw materials to consumers depends on the reliability of shipping facilities operation. Therefore, ensuring safety, preventing man-made and natural destructive events are urgent and priority tasks of the owners of such facilities. Among the incidents that can cause significant direct and indirect damage, the most dangerous are fires. In this regard, in order to make management decisions on fire safety, it is necessary to know the situation with fires, to understand their social and economic consequences, to be able to identify possible causes for fires both at construction infrastructure facilities (shipyards, docks, port facilities) and on watercraft. At the same time, an important component in making such decisions is the study of the effectiveness of the fire alarm as a primary element in the general technological systems of fire automation on shipping facilities.

Problem Statement. The objective of the study is to analyze the causes of fires and the operation of fire alarm systems at shipping facilities.

Theoretical Part. Based on statistical data on fires and their consequences for 2017-2021, the social (the number of dead and injured people) and economic (direct material damage) consequences of fires at shipyards, port facilities, watercraft (ships, boats, vessels) and docks are analyzed. Estimates of the effectiveness of fire alarm systems at shipping facilities are given.

Conclusions. The efficiency of fire alarm systems at all shipping facilities is on average at the level of 90%. At the same time, for sea and river vessels, this figure is about 82%, for port facilities it is almost 100%. But despite such a high level of fire alarm systems, it is not possible to avoid social and material consequences of fires. In addition, it should be noted that most fires occur at shipping facilities that are privately owned. At shipyards, port facilities and docks, fires on private property account for 71% of the total number of fires. On private sea and river vessels, the proportion of fires reaches 90%.

Keywords: shipping facilities, fire, statistical data, direct material damage, fire alarm, response efficiency.

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Introduction. The Decree of the President of the Russian Federation approved the foundations of the country's state policy in the field of fire safety [1]. New approaches to the prevention of fires, to the protection of human life and health, and the preservation of material values are formulated. One of the strategic objectives of the state policy is the task of determining fire risks at various hazardous facilities. Taking into account such assessments, measures are taken to form regulatory requirements for the fire safety system of various hazardous facilities. The latter, in particular, include shipping facilities, including buildings (structures) that are part of its infrastructure, as well as motor sea and river vehicles. An important component in fire risk assessment is to determine the effectiveness of the operation of various fire protection systems, in particular fire alarm systems (FAS). The use of efficient and effective FAS at hazardous facilities allows for the timely activation of the warning and evacuation management system, automatic fire extinguishing and smoke removal systems, as well as the transmission of information about the fire to the fire departments. The effective FAS functioning is directly related to the increase in the level of safety of people and a significant reduction in material losses in case of fire. The study of fire risks at shipping facilities makes it possible to determine the amount of fire protection requirements when concluding insurance contracts with the owners of shipping facilities, as well as the corresponding insurance rates and discounts (surcharges) on them.

In this regard, in order to assess the fire risk at shipping facilities, it is necessary to analyze the situation with fires, determine their social (the number of dead and injured people) and economic (direct material damage) consequences, as well as the causes of fires. In addition, it is also necessary to investigate the effectiveness of FAS operation, which is the primary executive element of automated fire protection control systems [2, 3]. Evaluation of the effectiveness of FAS operation at various hazardous facilities is given in publications [4, 5], they present methods and criteria for obtaining these estimates, as well as determining social and economic consequences of fires.

Problem Statement. In [5], the results of a study of the effectiveness of the FAS operation at various hazardous facilities are given. However, this study was conducted without a detailed analysis of the situation with fires at the considered hazardous facilities, as well as without comparing data on FAS operation and the consequences of fires. The features of the infrastructure of the studied hazardous facility are not determined. Based on this, it seems appropriate to assess the effectiveness of FAS functioning, taking into account the current situation with fires and their consequences. Such studies were conducted on the basis of data on shipping facilities.

Theoretical Part and Results. Statistical information of the Federal State Information System "Federal Data Bank "Fires" was used to analyze the situation with fires at shipping facilities [6]. The following objects of navigation are considered: buildings and infrastructure structures (shipyard, dock, port facility), vehicles (sea, river vessel, boat, speedboat). Data for 2017-2021 are taken for analysis. The sample was carried out for each year, and the average values of the studied indicator for a five-year period were determined.

When taking into account the social consequences of fires, the indicator (S) was studied — the number of victims (dead and injured) per one fire (person/unit). The calculation was carried out according to formula:

$$S = \frac{N_{\text{гиб}} + N_{\text{травм}}}{N_{\text{пож}}}, \quad (1)$$

where $N_{\text{пож}}$ — the number of fires during the period under consideration on the type of objects under consideration (units);

$N_{\text{гиб}}$ — the number of deaths during the period under consideration on the type of objects under consideration (people);

$N_{\text{тпм}}$ — the number of injured during the period under consideration on the type of objects under consideration (people).

Accordingly, accounting for material losses from fires was carried out using the indicator (M) — direct material damage from fires per fire (million rubles/unit). The calculation of the indicator (M) was carried out according to formula:

$$M = \frac{T_{\text{пож}}}{N_{\text{пож}}}, \quad (2)$$

where $T_{\text{пож}}$ — direct material damage from fires during the period under consideration on the type of objects under consideration (million rubles).

The method, criteria and corresponding calculated dependences for evaluating the FAS effectiveness under various modes of its operation and for the consequences of fires are given in publication [4]. The proposed approach to determining the FAS effectiveness is based on statistical data.

The following results of the analysis of the situation with fires and the assessment of the FAS effectiveness at shipping facilities were obtained (Fig. 1).

As it can be seen in the figure, during the analyzed period, the largest number of fires occurred on vehicles (sea and river vessels). According to the data shown in Fig. 2, the number of victims (dead and injured) in fires per one fire (1) is distributed approximately equally among vehicles and is on average 0.153 people/unit.

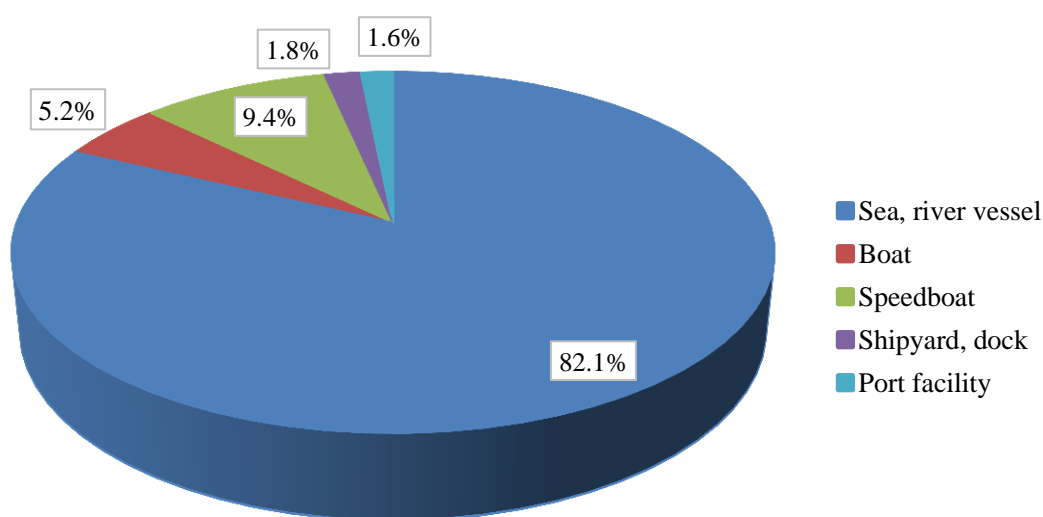


Fig. 1. Distribution of the number of fires by shipping facilities (percentage of the total number)

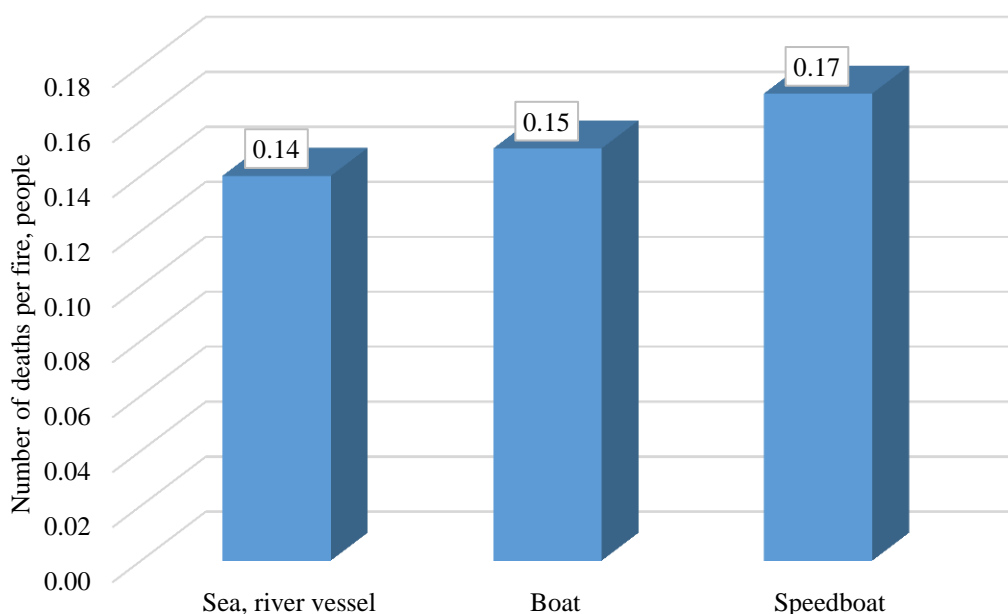


Fig. 2. Number of victims (dead and injured) per one fire on shipping vehicles, people/unit

The greatest direct material damage per one fire was registered on sea and river vessels (Fig. 3). On average, it amounts to 1,295 thousand rubles per fire. Accordingly, the least direct damage was registered on fires in port facilities — 39 thousand rubles per fire, at shipyards and docks — 9 thousand rubles per one fire.

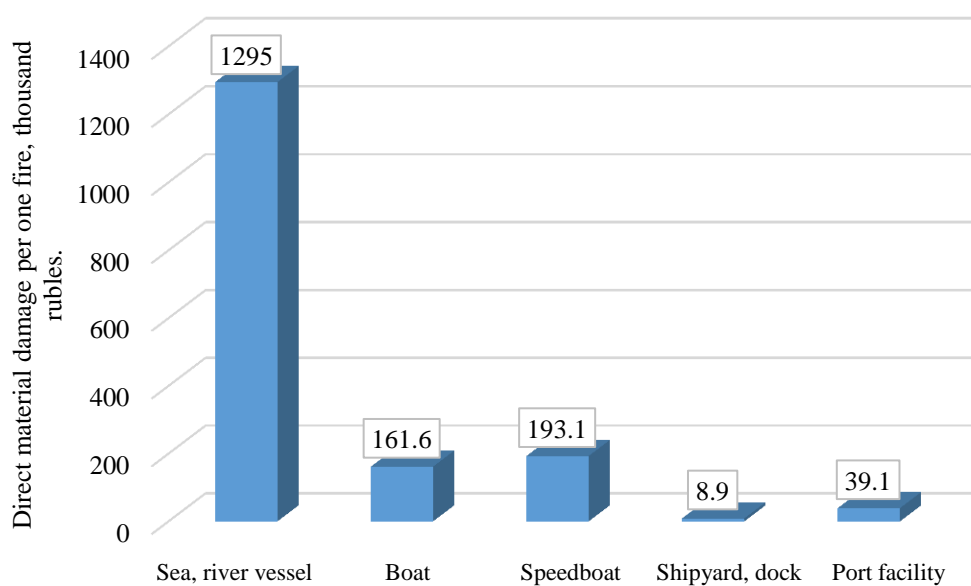


Fig. 3. Direct material damage per one fire, thousand rubles/unit

The study of the causes of fires at shipping facilities gave the following results. Figure 4 shows data on fires that occurred on sea and river vessels, their causes. Most of the fires occurred due to violations of fire safety rules during electric and gas welding and fire works (24.5%), due to careless handling of fire (19%) and violations of the rules of installation and operation (VRIO) of electrical equipment (17.9%).

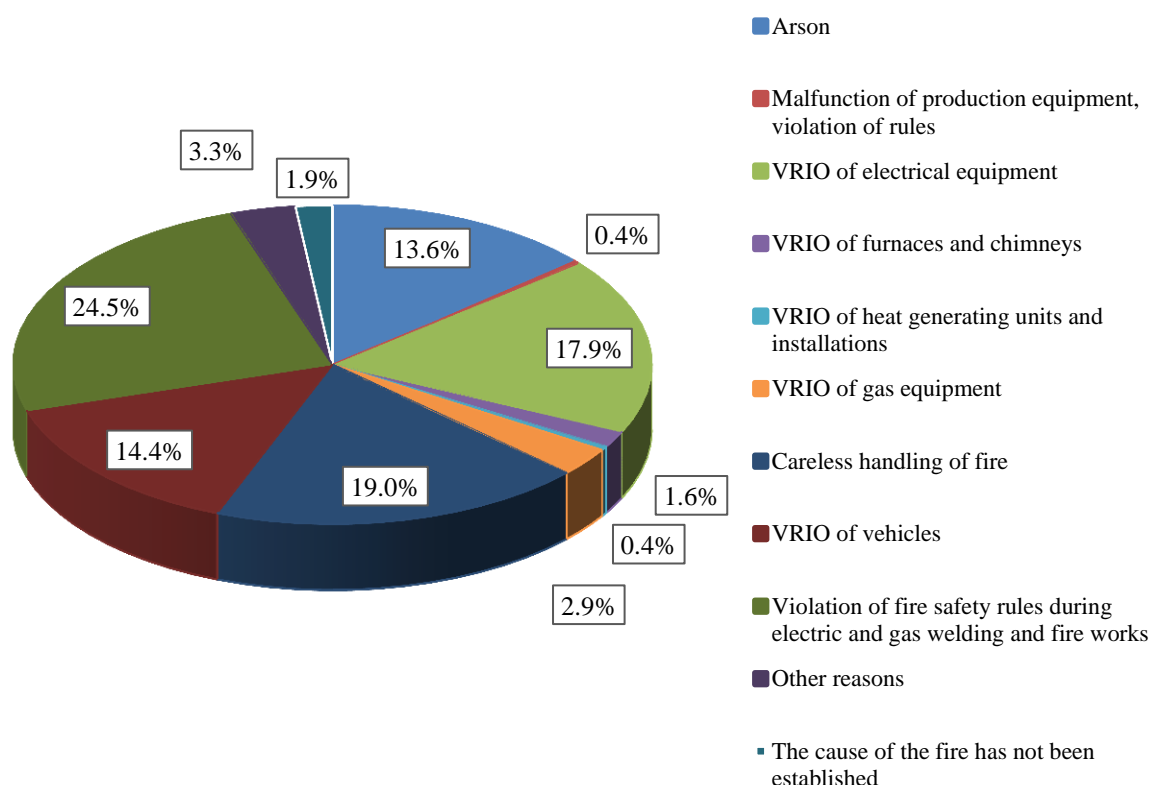


Fig. 4. Number of fires that occurred on sea and river vessels, their causes, %

As it can be seen in Fig. 5, in the fires that occurred on sea and river vessels, most people die due to careless handling of fire (41.2%), as well as for an unknown reason (29.4%). Injuries to people in fires most often occur due to violations of the operation of vehicles (29.6%) and the operation of electrical equipment (16.7%) (Fig. 6). The greatest direct damage from fires on sea and river vessels was caused due to violations of the rules of operation and installation of electrical equipment — more than 81% of the total direct damage (fig. 7).

The analysis of fires at port facilities, shipyards and docks showed the following: most fires occurred due to violations of the rules of operation and installation of electrical equipment (35.3%) and due to careless handling of fire (23.5%) (Fig. 8).

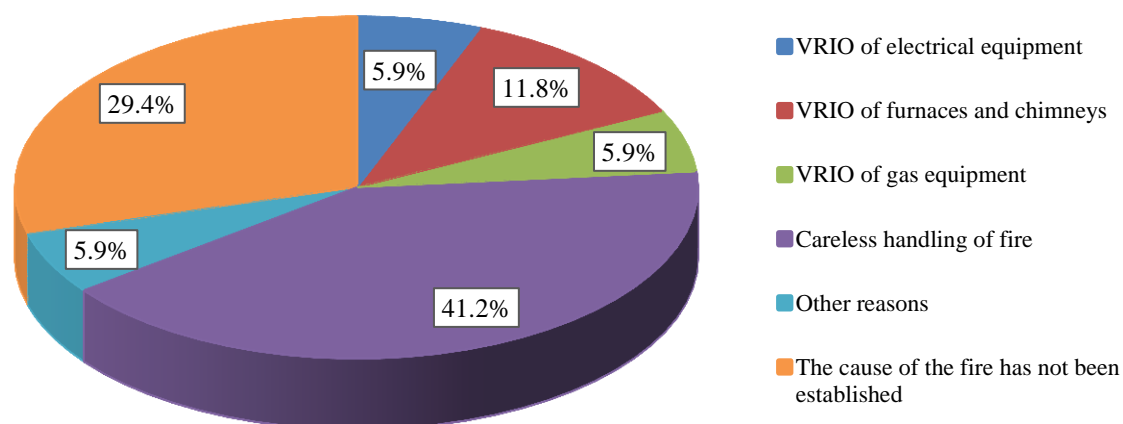


Fig. 5. Number of deaths in fires that occurred on sea and river vessels, their causes, %

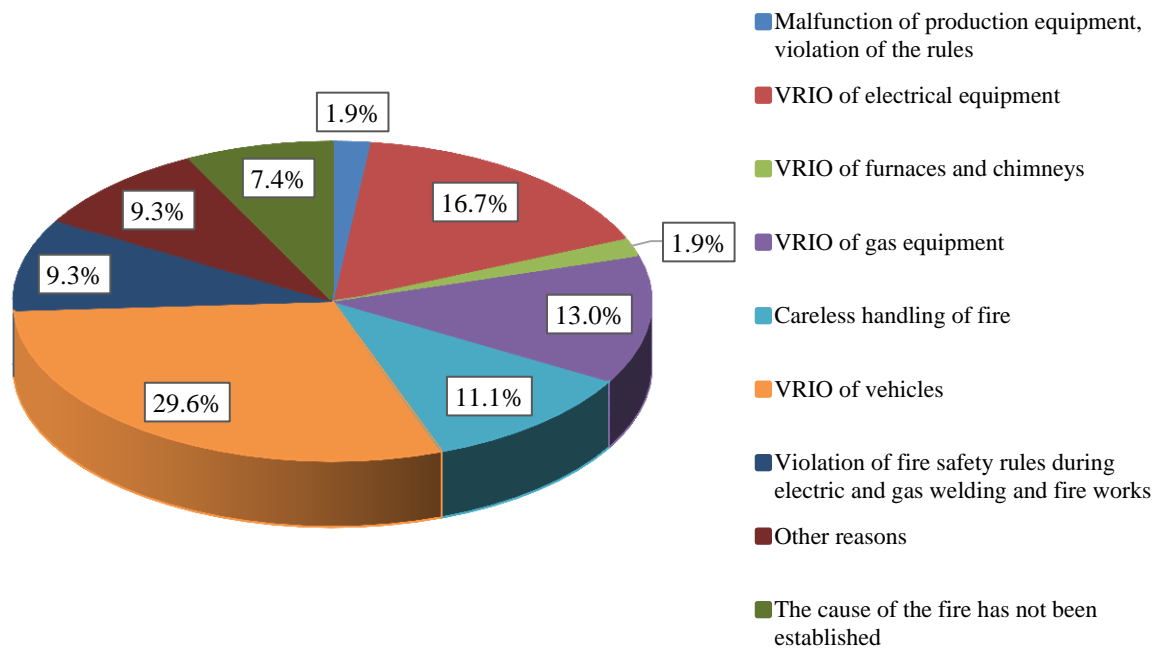


Fig. 6. Number of injured people in fires that occurred on sea and river vessels, their causes, %

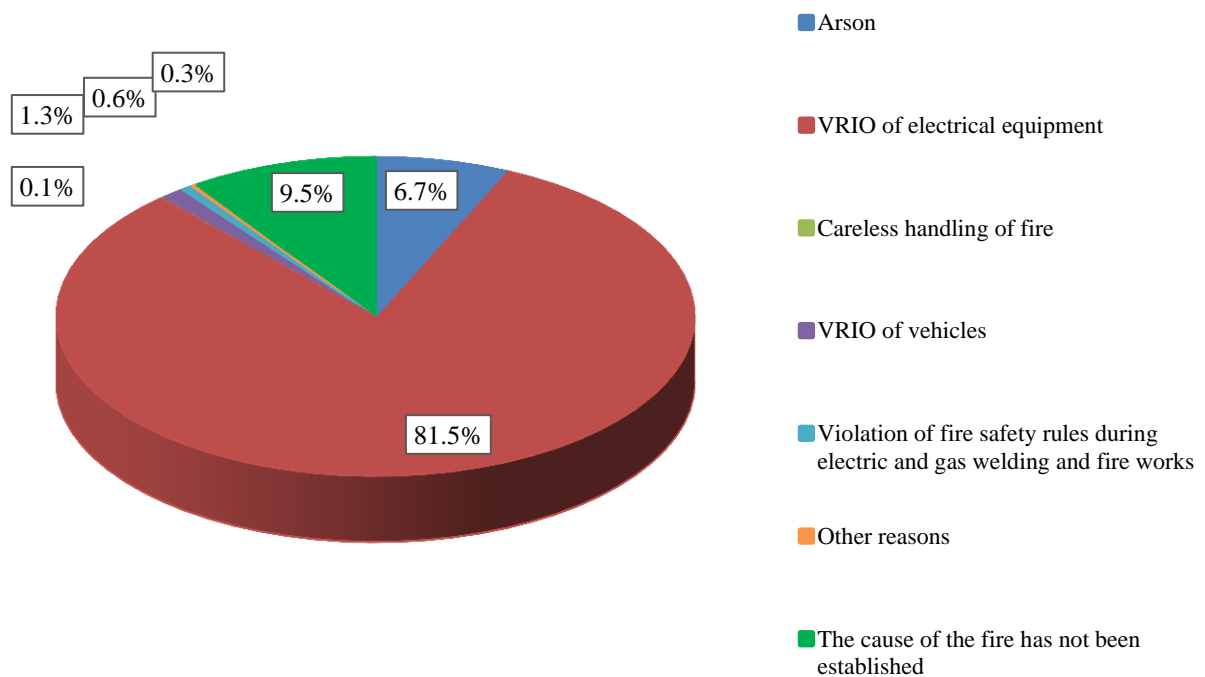


Fig. 7. Direct damage from fires that occurred on sea and river vessels, their causes, %

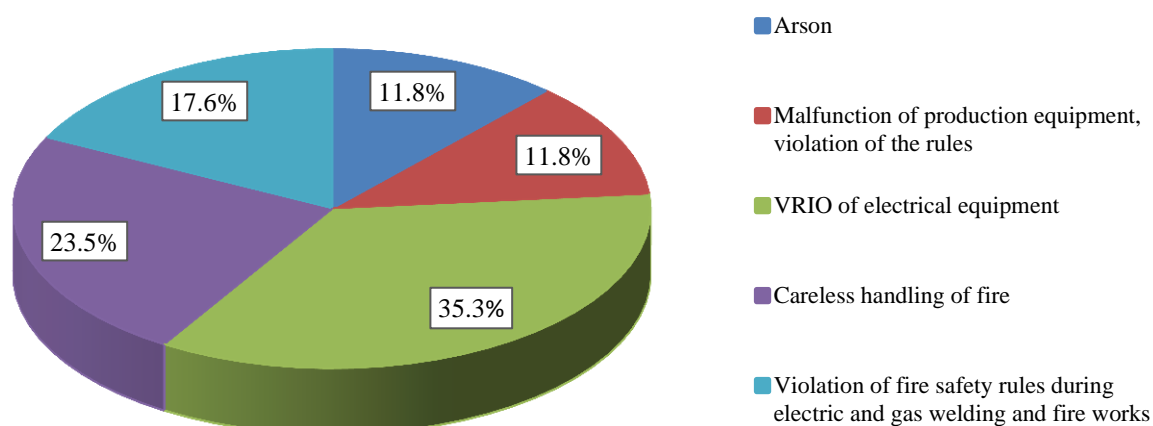


Fig. 8. Number of fires that occurred at port facilities, shipyards and docks, their causes, %

For insurance purposes, the studies of the situation with fires from the point of view of the forms of ownership of shipping facilities are of considerable interest. The interest in this kind of research is due to the fact that since 2016, a risk-oriented approach to the system of organizing inspections by supervisory authorities began to be introduced in the country, when the rigor of the implementation of control measures began to depend on the risk category of the subjects being checked, which undoubtedly affected the fulfillment of the requirements for ensuring fire safety of hazardous facilities by owners [7].

The analysis of the situation with fires and their consequences at shipping facilities by form of ownership (federal, property of a subject of the Russian Federation, municipal, private) showed the following. Figure 9 shows that most fires occur at shipping facilities that are privately owned. At port facilities, shipyards and docks, fires on private property account for 71% of the total number of fires, and on sea and river vessels the share of such fires reaches 90%.

On sea and river vessels, the biggest amount of deaths per fire is observed on objects of a different (non-private) form of ownership — 0.08 people per one fire with 0.03 people per one fire for private property objects (Fig. 10). The number of injured per one fire on private property is 0.11 people with 0.13 people per one fire at objects of other types of property.

Figure 11 shows data on the distribution of the material consequences of fires at shipping facilities, depending on the types of their property. The greatest direct damage per one fire on sea and river vessels was caused to objects of private property, while on objects of other forms of ownership this damage is 17 times less.

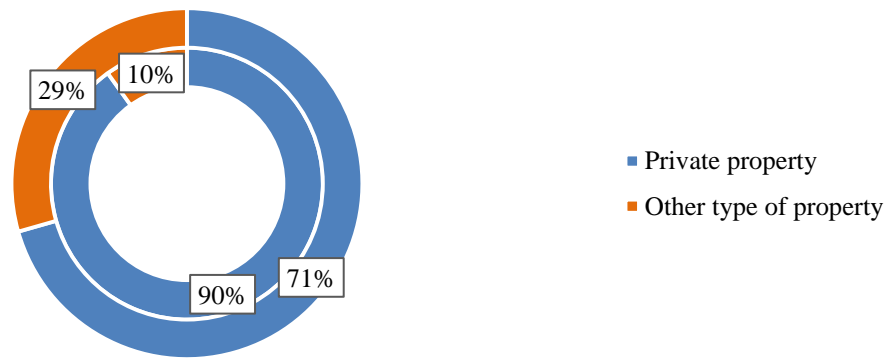


Fig. 9. Number of fires that occurred at port facilities, shipyards and docks (external diagram), on sea and river vessels (internal diagram), depending on the form of their ownership

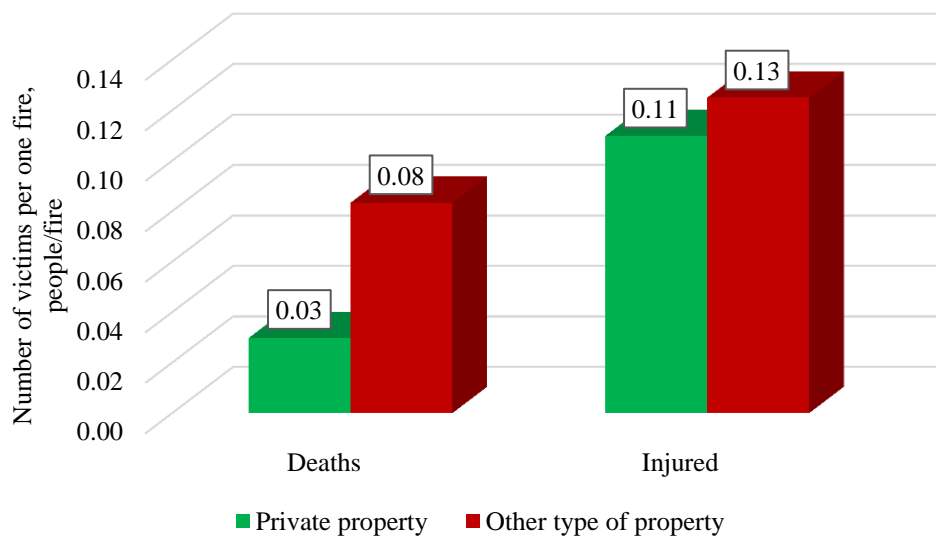


Fig. 10. Number of dead and injured people in fires that occurred on sea and river vessels, depending on the form of ownership

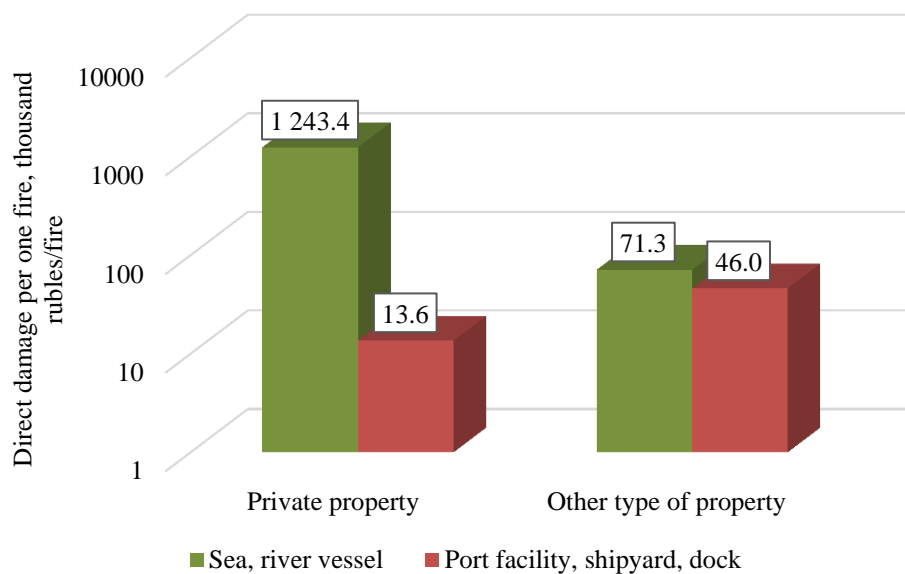


Fig. 11. Direct damage per one fire at shipping facilities, depending on their form of ownership (logarithmic scale is used along the ordinate axis)

As noted earlier, the basis for the construction of fire protection systems are FAS — primary actuating elements, on the reliability of which the activation of other fire automation systems designed to ensure the safety of people and the performance of fire extinguishing functions depends. The results of the assessments of the effectiveness of FAS response at shipping facilities are shown in Fig. 12. As it can be seen in the diagram, the efficiency of FAS operation on sea and river vessels is 82%, at port facilities it reaches 100%.

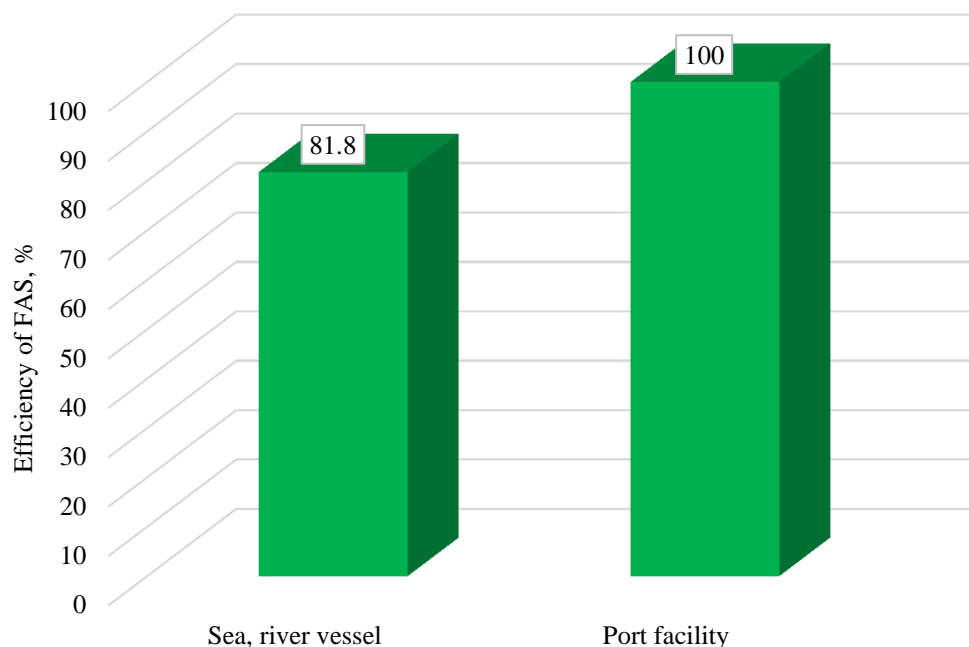


Fig. 12. Efficiency of FAS response at shipping facilities

It should be noted that with such a high level of FAS operation, according to the analysis of the consequences of fires (Fig. 3, 5-7), significant social and material losses from fires at shipping facilities are still observed, which may be due to the low efficiency of other automatic fire protection systems, such as the warning and evacuation management system, smoke ventilation, automatic firefighting system.

Conclusions. The study of statistical data on fires and their consequences at shipping facilities for 2017-2021 showed the following. During this time, fires occurred mainly on sea and river vessels. The greatest direct material damage from fires (1,295 thousand rubles per fire) was also registered on sea and river vessels.

The main causes of fires that occurred on sea and river vessels are violation of fire safety rules during electric and gas welding and fire works (24.5% of the total number of fires), careless handling of fire (19%) and violation of the rules of operation and installation of electrical equipment (17.9%). At shipyards, port facilities and docks, fires most often occurred due to violations of the rules for the installation and operation of electrical equipment (35.3%), careless handling of fire (23.5%). There is a fairly high level of arson at these shipbuilding facilities (11.8%).

The study also showed that most fires occur at shipping facilities that are privately owned. On private property in port facilities, shipyards and docks, they account for 71% of the total number of fires, and on sea and river vessels the share of such fires reaches 90%.

The effectiveness of FAS operation at shipping facilities is significant. For sea and river vessels, it is almost 82%, for port facilities — 100%. Nevertheless, with such a high level of operation of fire alarm systems, social and material consequences of fires are noted.

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A. A. Poroshin — formulation of the concept of the article, goals and objectives of the study, calculations, preparation of the text, formulation of the conclusions; V. L. Zdorov — preparation of literary sources, conducting and analyzing the calculations results; N. V. Semenenko — preparation of the text and source data for calculations; I. V. Volkov — preparation of literary sources and source data for calculations.