Environmental risks of accidental pollution during oil spills at water transport

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Abstract. The paper is devoted to the problem of protecting the environment from accidental environmental pollution from oil spills. Protection against this type of pollution is provided by a set of organizational measures and technical means that are aimed at preventing the occurrence of an accidental spill, stopping the flow of oil into the environment, eliminating the spill and eliminating its consequences. The development basis for a complex of protective measures in the form of a system including organizational measures and technical means was determined. This complex includes an operational procedure, the implementation of which provides effective protection against accidental pollution. The environmental risk assessment algorithm for emergency pollution of the environment during oil spills includes forming technical device groups for each technical object intended for moving oil. For each group, the environmental risk assessment is carried out by determining possible damage and the probability of an accidental spill, the causes of accidental spills are analyzed as well.

1 Introduction

At the present time, inland waterway transport is actively used to deliver oil and petroleum products to consumers [1,2]. The delivery process includes the temporary storage and transshipment of oil or petroleum products in ports, as well as their transportation by ships. In general, such a number of technological operations with oil and a large amount of oil transported determine a high level of environmental hazard, especially in cases of accidental oil spills.

Accidental oil spills cause great environmental damage to the environment and, above all, water resources. In addition, such cases are characterized by material damage associated with the loss of a commodity product – oil or petroleum products. Therefore, the problem of preventing water pollutions during oil spills continues to be urgent [3-5].

At this point, some experience has been gained in solving the problem of preventing accidental pollution caused by oil spills, mainly in the field of creating and applying technical devices for spill response [6]. Analyzing this experience and the eye of the problem at the same time shows that the solution should not be limited only to measures

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aimed at responding oil spills [7,8]. The main methods which allow preventing the accidental environmental pollution during oil spills were formulated in the research [7]. The laid down methods are derived from the characteristic analysis of the accidental pollution processes. The contributors of the research [9–13] note the main characteristics of phenomena similar to oil spills. They combine these phenomena under the name of emergency environmental pollution. The above-mentioned characteristics of accidental pollution of the environment include, above all, the uncertainty of such cases in terms of the time and location of emergency pollution, as well as their causes and possible damage.

In general, the prevention of accidental environmental pollution, including oil spills, should include preventing the occurrence of an accidental spill, stopping the flow of oil or oil products into the environment, eliminating the spill and its consequences. Each of these points represents its own complex of organizational measures and technical means, which contents depend on various factors and cannot be the same for all cases of a possible oil spill.

2 Methods and materials

Developing the complex of protective measures should be subjected to certain rules that constitute the theoretical basis for the development of protective organizational measures and technical means. The paper contains a summary of these theoretical foundations.

As is known, the accidental contamination's danger level of any object, which ensures the fulfillment of a certain transportation stage of oil or petroleum products, is characterized by a risk that indicates the likelihood of contamination and possible damage [6, 9, 13]. Therefore, the development of risk management methods should be the basis for protecting the environment from pollution by man-made objects, including water transport facilities [13-16].

Two main types of objects can be distinguished considering the oil transportation process: stationary and non-stationary. The first includes ports and other structures, such as floating complexes, which provide temporary storage and transfer of oil. The second type includes vessels that provide oil transportation, that is, its movement over distances larger than the size of the object for storage and handling of oil.

Developing the set of protective measures, i.e. a system of organizational measures and technical means, should be aimed at objects and situations that are characterized by the highest environmental risk. That leads to the natural conclusion about the need to assess the possible environmental risks of technical objects used to transfer oil.

Environmental risk assessment should be carried out separately for each object that provides the movement of oil or petroleum products, since each object represents a specific technical structure and is characterized by unique technical characteristics and service conditions.

In turn, each of these objects is a system of technical devices, which can be a direct source of emergency release of oil or petroleum products into the environment. Considering that the design and purpose of technical devices, the causes of emergency situations which led to loss of tightness, as well as protective measures, can be identical, it is advisable to group all such devices into several types. These types are pipes (or pipe systems), vessels, pumping devices and junctions.

In addition, when moving oil or petroleum products within the boundaries of a single object, which is a combination of different device types, the risk of an accidental spill will vary (Fig. 1). Therefore, protective measures should be primarily aimed at those groups of technical devices, which are characterized by the greatest risk (indicated by the dotted line).

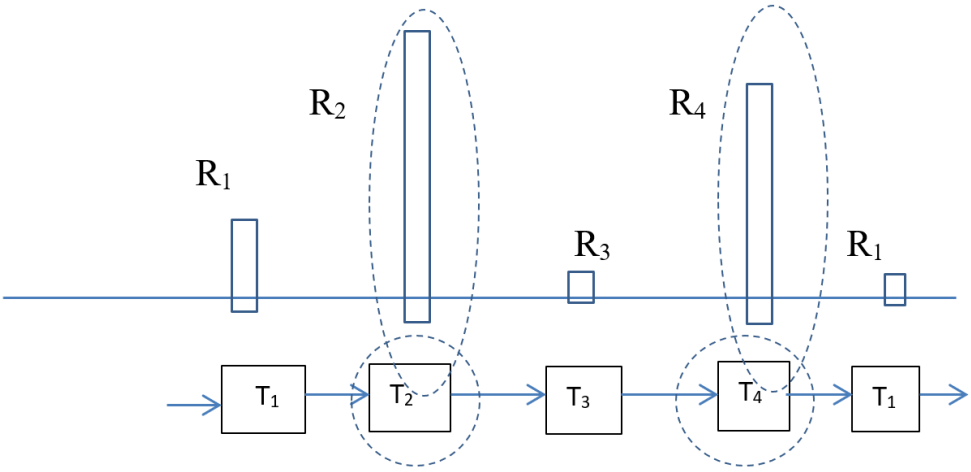

Fig. 1. The distribution of the risk magnitude for different component groups of man-made objects.

The nature and content of protective measures is determined by the risk structure. As mentioned above, the risk, being the product of probability and possible damage, indicates these characteristics of the spill. Therefore, it is important to determine the magnitude of the component that will prevail in the risk value. This can be reached by analyzing the structure of the risk value. Another factor determining the nature and content of protective measures is the cause of the spill. Moreover, considering the same group of technical devices (components), different causes of accidental pollution can be characterized by different risk values. Firstly, it is clear that the causes must be considered when studying the risk of accidental pollution at the facility. Secondly, protective measures should be directed to those factors that are characterized by the greatest risk.

Thus, in general, the main factors determining the content of protective measures are the type of technical device, the structure of the risk and the causes of accidental pollution (Fig. 2).

3 Results

Analysis of above mentioned factors allows to develop a local planimetric map (key plan) of the considered object. It is a direct information source allowing to form a complex of protective organizational measures and technical means. The local planimetric plan primarily includes information on those groups of technical devices, causes and circumstances that are characterized by the greatest risks. That means, that for those types the occurrence of emergency situations, for example, oil spills, is the most likely and may be accompanied by the greatest damage.

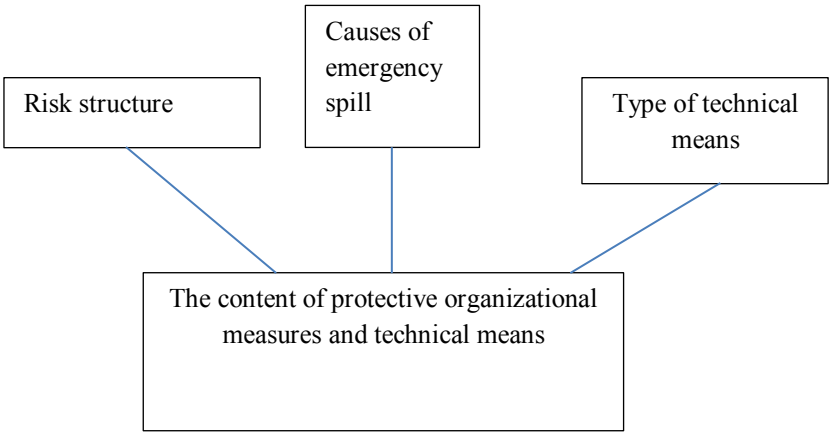

Fig. 2. Formation of a protective measure complex.

The above mentioned results of studying the occurrence processes of emergency environmental pollution, for example, the oil spills, allow us to formulate the following risk assessment algorithm for water transport facilities that are used for transportation of oil or petroleum products:

- developing the groups of technical devices as components of the considered object on the basis of their typification, depending on the constructional characteristics and service conditions;
- assessing the possible damage from accidental pollution for each group of technical devices as part of the risk structure study;
- analyzing the obtained values of the occurrence probability (frequency) of accidental pollution for each group as part of the risk structure study;
- adjusting the content of groups, considering results of risk structure analysis;
- analyzing the causes of accidental pollution characterized by the highest values of environmental risks;
- developing the local planimetric map (key plan) of the considered object;
- developing a complex of protective measures including organizational measures and technical means.

4 Discussion

The experience of preventing hazards that humanity encounter during the existence and protecting against them, including those such as accidental environmental pollution, shows that the uncertainty of such processes is the main difficulty in solving this problem. Uncertainty can relate to location or time, as well as to possible causes and damage value. Understanding the significance of hazard's random nature is reflected in the word "risk", which is constantly found in the studies of various hazard manifestation cases. In general, protection from hazards can be provided by regulating these processes, which reduces the probability of accidental pollution and possible damage. The regulation of any process begins with the establishment of a parameter that most objectively characterizes the regulated process. In the field of protection against accidental environmental pollution such a parameter is the risk, which is the product of the probability for damage. However, it is not always understood in this way by specialists involved in environmental protection issues, including those on water transport. At the same time, the definition of risk as a parameter characterizing both probability and possible damage has a profound meaning. It

opens up the main possibilities to specialists for solving the problem of protection against accidental pollution, for example, in case of an oil spill. Such an approach to understanding the processes of emergency environmental pollution during operation allowed the contributors to develop an algorithm for assessing the risk of water transport facilities. On its basis a set of organizational measures and technical means can be developed in order to provide effective protection against accidental pollution.

5 Conclusion

The approach to the understanding of environmental problems in water transport proposed by the contributors allows to represent the negative impact of water transport facilities as two types of pollution: operational and emergency. Emergency pollution is characterized by uncertainty and it is proposed to use the risk parameter to characterize it. It is the product of the probability of accidental pollution for damage. In turn, from the point of system perspective, contributors proposed to organize the protection of the environment from accidental environmental pollution in the following ways: reducing the probability of emergency situations and damage by preventing the flow of pollutants into the environment in the case of an emergency. The described approach allows to develop an effective set of organizational measures and technical means, which is formed on the basis of the local planimetric plan of the considered object. The set includes information on technical devices as possible sources of accidental pollution, causes and circumstances that are characterized by the greatest risk of accidental pollution. An algorithm is proposed for developing a local planimetric plan.

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