# CLASSIFICATION OF ACCIDENTAL OIL SPILLS IN OIL EXTRACTION AND ASSESSMENT OF ENVIRONMENTAL RISKS

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**Abstract**

*The distribution and characteristics of the results of accidents in oil pumping and hydrocarbon transportation systems by degrees of severity are given in separate categories. A new methodical approach was proposed for the evaluation of the ecological and economic risk factor.*

**Keywords:** risk, environmental damage, oil spill, environment, accident probability

## I. Introduction

One of the factors that most affect economic indicators in oil extraction is the spillage of oil into the environment due to accidents. In addition to disrupting normal work regimes, accidents cause significant operating difficulties and material losses, seriously damage the ecological balance of the environment, and create fire and explosion risks [1-3]. The consequences caused by oil spilled into the marine environment are greater, and the elimination of the consequences of such accidents requires considerable cost and time (Fig. 1).

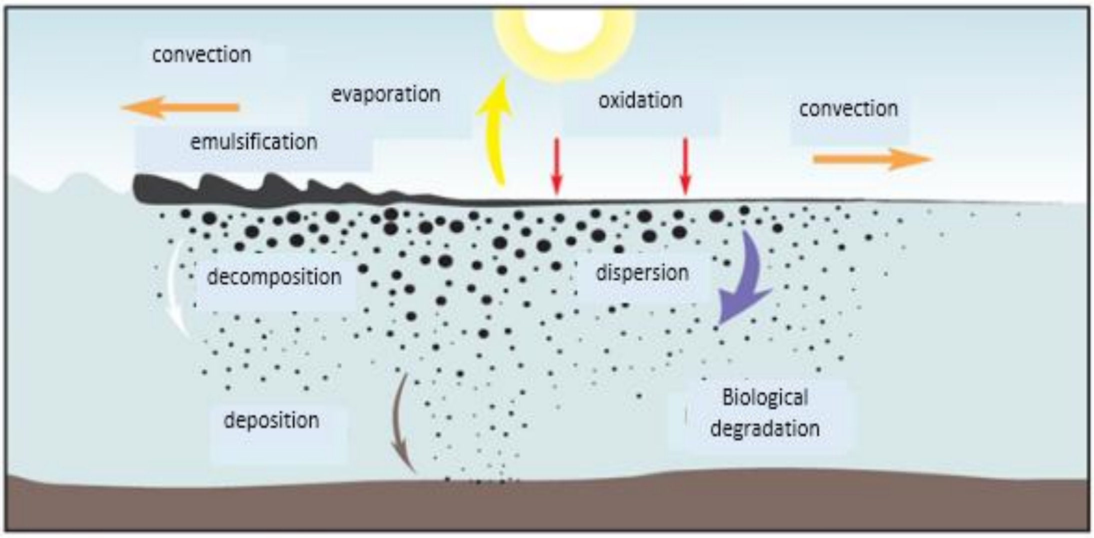


**Fig.1:** *Spread of oil spilled into the sea*

## II. Methods

The analysis of accidents occurring in oil extraction and hydrocarbon transportation systems shows that accidents are significantly different from each other according to the degree of severity of the consequences. It is accepted to classify accidents into 5 categories according to severity [4-7]. The deviation of accident frequencies by different accident categories is shown in Table 1.

The interpretation of the results of accidents by degrees of severity in separate categories is shown in Table 2.

**Table 1:** *Deviation of accident frequencies by categories*

| Categories | Accidents | Approximate frequency of accidents | Characteristics of accident probabilities |
|---|---|---|---|
| 1 | Practically impossible | $< 10^{-6}$ 1/year or once in more than 1 million yeras | Although such cases are not excluded, they almost never happened. |
| 2 | Rarely | $(10^{-6} - 10^{-4})$ 1/year or once in $10^4 - 10^6$ years | These cases have happened only a few times worldwide. |
| 3 | Unlikely | $(10^{-4} - 10^{-2})$ 1/year or once in 100-10000 years | This kind of accident happens, but it is unlikely during the implementation of one project . |
| 4 | Probable | $(10^{-2} - 1)$ 1/ year or once in 100 years | Such an accident is possible when a project is realized. |
| 5 | Practically unavoidable | >1/ year or once in 1 year | On average, it can happen no less than once a year. |

**Table 2:** *Categories of accidents by degrees of severity and characteristics of their consequences*

| Categories of severity of accidents | Characteristics of the consequences of accidents |
|---|---|
| Imperceptible | It does not affect the health and safety of the population. There is no damage or breakage in the facility, there is no impact on natural resources. |
| Less valuable | There are no human deaths or serious injuries, the facility is slightly damaged, there is no idle situation, and there is a light and short-term impact on the environment. |
| Serious | Serious damage to facilities and loss of lives is possible among workers, but there is no fear for the health and life of people among the population, although there are negative, ultimately renewable effects on a number of natural resources. |
| Very serious | Casualties and injury to large number of workers working at the facility, significant damage to the facility, and significant and long-term damage to two or more natural resources are possible. |
| Catastrophic | The occurrence of an emergency that results in large numbers of human casualties and irreparable damage to large numbers of natural resources. |

Based on the currently available operating experience, oil leaks from pipelines can be divided into the following categories according to the size of the leak and the amount of spilled oil [2-4]:

- small leaks: Such leaks can occur from holes with a diameter of 5-10 mm (average 7.5

mm), which corresponds to the size of holes caused by corrosion in belts;

- medium leaks: holes varying in size from 10 to 50 mm;
- major leaks. Sizes of leakage sites greater than 50 mm;
- "hidden" or hard-to-detect leaks: leaks in pipelines of up to 3% of nominal flow or very small leaks.

Depending on the amount of oil spilled into the environment the value of oil loss due to an accident $Gn.i$ can be determined as follows:

$$Gn.i = Gn.s.q \cdot gts \quad (1)$$

where: $Qn.s.q$- sale price or cost of crude oil, AZN./t; g - the amount of oil spilled into the environment per unit time, t/h; $ts$- the time period for oil leakage into the environment, hours (in calculations, it is considered as the time of detection of the leak).

According to the analysis, in cases where leaks are detected after the nominal time has passed, rather than on time, there will be a corresponding increase in the amount of material damage caused. If "hidden" leaks during operation remain undetected for 1 month, then the damage caused by oil losses for pipelines with nominal consumption values of 10, 50, 100, 200, t/h can be valued at 5.4; 27; 108; 270 thousand AZN respectively. Thus, the assessment of damage caused by oil spills alone shows that the most important condition is first of all the quick, operative detection of leaks. On the other hand, special attention should be paid to small, including "hidden" oil leaks. In many instances, the damage and complications resulting from such leakage cases can be more severe and impactful from both a material and environmental standpoint than those cases that are detected at a later time.

The experience of oil extraction shows that the factors most influencing the occurrence of accidents and failure of oilfield equipment and pipelines are related to corrosion-erosion processes. It is not coincidence that a (5x5) risk matrix was drawn up based on the analysis to assess the risks of stopping from erosion-corrosion (Table 3). At this time, the level of risk was assessed as follows: 1.2 - very low; 3.4 - low; 5...10 - average; 12...16 - high; 20...25 - very high [8].

**Table 3:** *5x5 risk matrix for assessing the risk of corrosion stoppages in technological pipelines*

| Parameters that determine the risk | | Consequences of corrosion stoppages | | | | |
|---|---|---|---|---|---|---|
| | | Very low | Low | Average | High | Very high |
| Probability of stoppages from corrosion | Very high | 5 | 10 | 15 | 20 | 25 |
| | High | 4 | 8 | 12 | 16 | 20 |
| | Average | 3 | 6 | 9 | 12 | 15 |
| | Low | 2 | 4 | 6 | 8 | 10 |
| | Very low | 1 | 2 | 3 | 4 | 5 |

## III. Results

Considering that as the amount of oil spills increases, environmental damage and oil losses increase, and if we accept the probability of losses and damages $P_z$, then the probability of risk ($P_R$) can be defined as follows, considering the probability of oil spills ($P_{n.d}$) [5]:

$$P_R = P_{n.d.} \bullet P_z \quad (2)$$

The variation of the probability of P_R calculated according to equation (2) depending on the rate of oil spillage into the environment $q/Q_0$ ($Q_0$ is the consumption of oil in the pipeline before spillage) is shown in Fig.2.

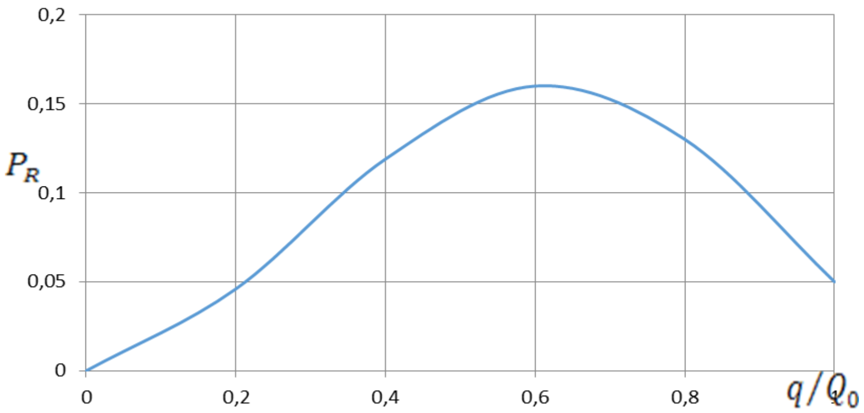


**Fig. 2:** *Changes in risk probabilities depending on the degree of oil spills into the environment*

## IV. Discussion

Fig.2 illustrates that the highest likelihood of accidental oil spill risk is represented by a maximum probability of $P_{Rmax}$ = 0.15. This level of risk, which is not particularly high, corresponds to the value of $q/Q_0$ =0.6 for the major leakage category. If we mark the price of the maximum economic damage caused by oil spills with Z, then it becomes clear that the maximum risk is $R_{max}$ =0.15 Z and will occur with a probability of 0.15.

It should be noted that, although the probability of the risk is much lower, since it is related to dangerous objects and coincides with large oil spills ($q/Q_0$ =0.6), its consequences can be quite sad.

Accidental oil spills that occurs during oil extraction and transportation were classified and the material and economic damage were assessed separately, including "hidden" leakage cases, and a methodical approach was proposed for the evaluation of the environmental and economic risk factor.

## References

[1] Instructions for accounting oil during its transportation. – Ufa: VNIISTPneft', 1995, 68 s. (in Russian)

[2] Ismayilov G., Ismayilova H., Babirov H., Jabrayilova R. Assesment of environmental oil spills and economic-environmental risks. RT&A, Special Issue № 4 (70) Volume 17, November 2022

[3] Control of leaks of oil and oil products on main pipelines during operation. – M.: VNIIOENG, 1981, s. 2-16. (in Russian)

[4] Kravchenko V.F. Environmental protection during transportation and storage of oil and oil products // Reviews of foreign literature. – M.: VNIIOENG, 1976, 60 s. (in Russian)

[5] Ismayilova H.G. On the assessment of damage from accidental losses' for various categories of oil leaks / Proceedings of the 69th International Scientific Conference "Oil and Gas" - 2015". – M.: 2015, s. 98. (in Russian)

[6] Kremmer V.H. Oil and oil products leakage control system from pipelines // Transport and storage of oil and oil products. Foreign experience: Exp. – M.: VNIIOENG, 1980, s. 21-30. (in Russian)

[7] RD Methodological Guidelines for Assessing the Risk of Accidents at Trunk Oil Pipelines. – M.: NTTS on Safety in Industry of Gosgortekhnadzor of Russia. 2012, 120 s. (in Russian)

[8] Yorf P., Kichenko A. Problems of corrosion in the pipelines of the oil gathering system and ways to solve it. International industrial portal. Innovation, 7 June 2011.