

## Artículo de investigación

**Environmental management system as a way of reducing the probability of technogenic accidents and environmental pollution at the airspace companies**

Система экологического менеджмента как средство снижения вероятности техногенных аварий и загрязнения окружающей природной среды на предприятиях авиакосмического комплекса

Sistemas de gestión ambiental como medio para reducir la contaminación y la probabilidad de accidentes en las empresas del sector aeroespacial

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**Abstract**

Due to the costs caused by environmental pollution, Russia loses about 10% of the gross domestic product (GDP) annually. The negative impact on the environment is exacerbated by industrial accidents. Enterprises from the category of hazardous industrial facilities must carry out preparations for emergency situations and industrial accidents. Accidents occurring at machine-building enterprises can also cause significant damage to the environment. Creation of environmental management systems at the enterprises will allow providing effective response to accidents at all types of enterprises, because one of the stages of the system implementation is preparation for emergency situations. At this stage, we consider the features of production and technological processes, the properties of hazardous substances used in production, we carry out the identification of possible emergency situations and environmental pollution arising from this, we select the most probable and large-scale emergency situations,

**Аннотация**

Из-за расходов, вызванных загрязнением окружающей среды, Россия ежегодно теряет около 10% валового внутреннего продукта. Негативное воздействие на окружающую среду усугубляется при возникновении промышленных аварий. Предприятия, относящиеся к категории опасных промышленных объектов, должны в обязательном порядке проводить работы по подготовке к чрезвычайным ситуациям и авариям на производстве. Аварии, возникающие на машиностроительных предприятиях, также могут наносить значительный ущерб окружающей природной среде. Создание на предприятиях систем экологического менеджмента позволит обеспечить эффективное противодействие авариям на всех типах предприятий, так как одним из этапов внедрения системы является подготовка к чрезвычайным ситуациям. На этом этапе рассматриваются особенности производства

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and we develop a system of measures that impede their occurrence and contribute to reducing their negative consequences.

**Keywords:** Emergencies, emergency preparedness, environmental pollution, environmental management system, emergency response.

и технологических процессов, свойства используемых в производстве и производимых опасных веществ, проводится идентификация возможных аварийных ситуаций и возникающих при этом загрязнений окружающей среды, выбираются наиболее вероятные и масштабные аварийные ситуации, разрабатывается система мероприятий, препятствующих их возникновению и способствующих уменьшению их негативных последствий.

**Ключевые слова:** загрязнение окружающей среды, противодействие чрезвычайным ситуациям, подготовка к аварийным ситуациям, система экологического менеджмента, чрезвычайные ситуации.

## Resumen

Los costos causados por la contaminación ambiental generan a Rusia unas pérdidas anuales de alrededor del 10% de su producto interno bruto. El impacto negativo sobre el medio ambiente se ve agravado por los accidentes industriales. Las empresas que pertenecen a la categoría de instalaciones industriales peligrosas deben estar debidamente preparadas para situaciones de emergencia y accidentes industriales. Aquellos accidentes que ocurren en empresas de construcción de maquinaria también pueden causar daños significativos al medio ambiente. La creación de sistemas de gestión ambiental permite proporcionar una respuesta efectiva a las emergencias en todo tipo de empresas, ya que una de las etapas de la implementación del sistema es la preparación para situaciones de accidente. En esta etapa, se toman en consideración las características de los procesos tecnológicos y de producción, las propiedades de las sustancias peligrosas utilizadas, la identificación de posibles situaciones de emergencia y la contaminación ambiental derivada de la actividad industrial. Tras ello, se desarrolla un sistema de medidas que reducen significativamente tanto el riesgo de que dichos accidentes se produzcan como las consecuencias negativas de los mismos en caso de que sucedan.

**Palabras clave:** Accidentes, contaminación ambiental, preparación para emergencias, respuesta a emergencias, sistema de gestión ambiental.

## Introduction

One of the actual problems is ensuring the security of the individual, society and the state. The concept of it is very multifaceted. One of the aspects is environmental safety, which is given by serious attention at the national and international levels. In 2015, the United Nations (UN) General Assembly adopted the document "Sustainable Development Goals for the Period until 2030", aimed at solving environmental problems and creating favorable conditions for human life (UN General Assembly, 2015). But, despite the efforts of the international community to reduce environmental pollution and achieve sustainable development goals, the problem of ensuring environmental safety is actual.

According to Federal Service for Supervision of Natural Resources, in 2016 in Russia the total amount of pollutant emissions into the atmosphere amounted to 31 617.1 thousand tons; 14.7 billion m<sup>3</sup> of polluted wastewater was discharged into water bodies; area of contaminated lands in economic circulation exceeds 75 million hectares; total volume of accumulated production and consumption waste in the country amounted to about 40.7 billion tons; high and very high levels of air pollution recorded in more than 20% of the cities (Federal Service for Hydrometeorology and Environmental Monitoring of Russia (ROSGIDROMET), 2017). The total cost of damage caused by high levels of environmental pollution is about 10% of GDP, and in regions

with high levels of pollution is 17% of GDP (Tishkov, Sdasyuk, Klyuyev, Korytniy, 2012). Environmental pollution caused by the operation of the industrial complex is exacerbated by the occurrence of industrial accidents. The emergence and development of accidents on the basis of "domino" effect is especially dangerous, it is when accidents at one industrial facility create conditions for the development of them at neighboring enterprises, or when major natural disasters cause technological disasters. In these cases, environmental pollution may become uncontrolled. According to the Institute of Market Problems of the Russian Academy of Sciences, the economic damage from environmental pollution resulting from accidents is about 38 billion rubles per year (Ryumina, 2007). The most negative environmental consequences arise from accidents at hazardous industrial facilities.

### Methodology

In 1992, the Declaration on Environment and Development was adopted in Rio de Janeiro. It recommends that states and manufacturers in their work be guided by the precautionary principle (PP) (Standartinform, 2015). Today, this principle is enshrined in international law, its compliance requires the manufacturer to have environmentally oriented behavior: the manufacturer should act aimed at reducing the negative impact on the environment, predict pollution that may occur during the development of production (release of new products, using new workshops, new materials, equipment and technologies) and to measure the estimated negative impact on ecosystems and benefits that will be obtained from the development of production (Kulikov, Makarenko, Sorokin, 2016).

In the seventies in Europe there were several major industrial accidents that led to significant environmental pollution. An analysis of these accidents showed that significant environmental pollution was the result of enterprises not being ready to act during the accidents that occurred. As a result, the Seveso directive (Directive 82/501/EEC) was adopted, which obliges manufacturers to develop plans for preparing for accidents and industrial emergencies aimed at reducing the possibility of them.

In Russia, in 1997, Federal Law No. 116 «On industrial safety of hazardous production facilities» was adopted, according to which industrial hazardous enterprises are required to develop a Declaration of industrial safety, which

is used to evaluate the characteristics of the production of hazardous substances used, plans for equipment placement, assessment of probabilities for the development of accidents, assessment of the consequences of accidents that occurred at the enterprise earlier, as well as assessment of neighboring industrial facilities objects and their possible impact on emergencies at the facility in question. The Declaration provides developed measures necessary to prevent accidents, mitigate their consequences and reduce direct costs of the state and enterprises (Makarenko, Sorokin, 2017).

Aircraft industry enterprises are not classified as hazardous production facilities, but, nevertheless, accidents at such enterprises can lead to serious pollution of the atmosphere, water bodies, and land pollution. Therefore, such enterprises are also advised to conduct a production analysis in order to prepare for emergencies that may be caused by malfunctions in technological processes, equipment failures, human errors and, as a result, lead to accidents and environmental pollution. One of the ways to comprehensively solve the problem of preparing enterprises for emergency response is the development and implementation of environmental management systems at enterprises in accordance with the requirements of state standard R ISO 14001-2016 «Environmental management systems. Requirements and application guidelines» (Standartinform, 2015). In the process of developing and implementing the system, the following work should be carried out (Galkina, 2017):

- Analysis of the conditions in which the company operates;
- Analysis of the requirements for the operation of the enterprise by the state, consumers, suppliers, partners, public, people living near the enterprise and other interested persons and organizations (Sorokin, Afonina, Galkina, Kirichenko, Chudakova, 2018);
- Assessment of risks associated with the operation of the enterprise, determination of environmental policy;
- Determination of environmental aspects of the enterprise and identifying the most significant of them;
- Distribution of duties within the framework of the environmental management system;
- Development of a program of work, which indicates specific performers of

planned activities, deadlines, achieved results;

- Conducting training for enterprise personnel and employees of contracting enterprises;
- Development of environmental management system documentation;
- Identification of possible emergency situations and preparation for them;
- Carrying out work to monitor the effectiveness of the system: monitoring the achievement of goals, monitoring the correctness of work;
- Internal audit of the environmental management system;
- Conducting an analysis by the enterprise management of the effectiveness of the system in order to determine directions for improving its work.

Thus, in the process of developing an environmental management system, an obligatory step must be completed. It is preparation for emergency situations and accidents. According to the requirements of the state standard R ISO 14001-2016, the enterprise must take measures to prevent such situations and reduce their negative impact on the environment. To do this, we must predict and analyze probable emergency situations and accidents, and develop measures aimed at preventing their occurrence and reducing environmental pollution.

In the process of performing the stage, it is necessary to collect information about the production and analyze the causes of possible accidents and their extent. It can be recommended to the company:

- To conduct an analysis of production processes, applied technologies;
- To compile a list of hazardous substances and materials used in production, to analyze their environmental impact;
- To compile a list of hazardous factors;
- To analyze the emergencies that occurred earlier in this enterprise and in similar industries (their causes, development, consequences, consider personnel errors, abnormal working conditions that led to their occurrence).

To identify possible emergencies, the enterprise is recommended to conduct an analysis of the workshops, production sites, technological operations, it is necessary to consider the

production site of the enterprise, the territory of the garage, warehouses, conditions for loading and unloading, transportation of goods, storage conditions for finished products, raw materials and semi-finished products, hazardous materials, fuels and lubricants and flammable substances, compressed gases, presence of pipelines, waste collection sites, etc. (Standartinform, 2017).

The enterprise should determine the possible causes of accidents that can occur under normal operating conditions, during commissioning and shutdown of production, as well as under abnormal operating conditions (for example, explosions, fires, chemical spills, uncontrolled chemical reactions, power outages, failures in gas or heat supply, failure of treatment facilities, gas leaks, personnel errors, etc.) (Sorokin, Bulychev, Novikov, Gorbachev, 2019). The analysis process should assess the potential negative impacts of the alleged incidents on the environment and ecosystems:

- Accidental emissions into the atmosphere of the pathway for dispersing harmful substances;
- Emergency discharges into water and land;
- Solid and liquid wastes generated, especially of the first hazard class;
- Physical pollution of the environment (noise, ionizing radiation, etc.);
- Pollution as a result of uncontrolled chemical reactions.

In addition to the analysis of our own production, an analysis of potential sources of danger located outside the enterprise should be carried out:

- At neighboring enterprises (to consider types of production at neighboring enterprises, storage of large volumes of hazardous substances, possibility of accidents and their consequences) (including natural ones)) (Galkina, Dainov, Sorokin, 2016):
- On objects of social infrastructure (large sports complexes, shopping centers, social institutions);
- At transport facilities (railway and highway);
- At natural sites;
- General, environmental situation in the region.

As a result of the analysis, a register of probable types of emergency situations and the direct and secondary environmental impacts caused by them is compiled (for example, failure of

treatment facilities can lead to accidental emissions and discharges, fire can lead to air pollution) (Standartinform, 2014). Then, the most probable and large-scale emergencies are selected from the register, the response plans of which should be developed in the first place, for this purpose it is recommended to "use a matrix of a qualitative risk assessment, which identifies

emergencies depending on their probability and consequences" (Table 1) (Petrosyan, 2009; Galkina, Sorokin, 2019).

Table 1. Qualitative risk assessment matrix

Qualitative probability assessment	Environmental impact		
	Insignificant	Moderate	Catastrophic
Almost certainly happen	Medium risk	High risk	Extremely high risk
Possible	Low risk	Medium risk	High risk
Rare or almost impossible	Low risk	Low risk	Medium risk

Today, the bow-tie scheme is quite well-known, which reflects the logic of the emergence in an accident and the possibility of stopping the development of events with the help of "safety

barriers" (Figure 1), which are installed at the factory to increase reliability in order to reduce equipment failures, personnel errors, etc. The use of such barriers is proposed in the Seveso II directive (Directive 96/82/EC).

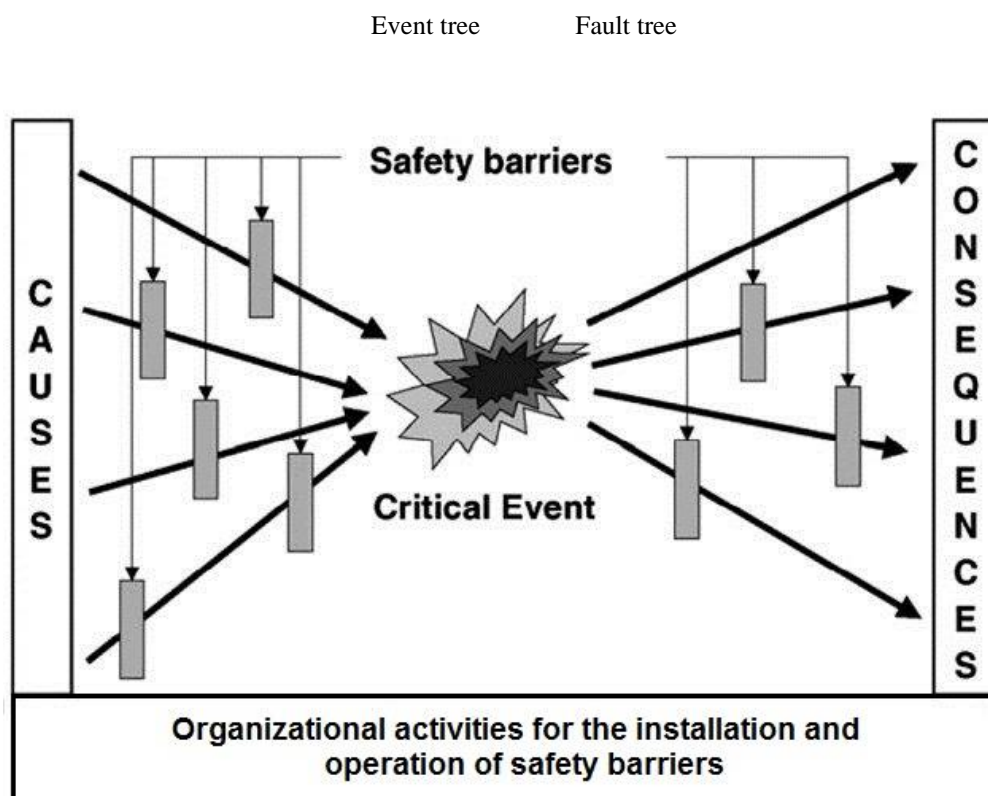


Figure 1. Relationship between technical and organizational security (Petrosyan, 2009)



Security barriers can be technical and organizational. Technical ones include, for example, increasing the reliability of equipment operation, use of protective shutdown systems, emergency power supply, safety valves, double walls for tanks. Organizational ones include timely updating of fixed assets, carrying out preventive maintenance, the use of automation of technological processes, staff training in emergency situations, etc. It is quite obvious that the correctness and effectiveness of the actions of personnel largely determines whether it will be possible to prevent the development of emergencies and prevent the occurrence of an accident (Belyavskiy, Novikov, Sorokin, Shangin, 2019). Therefore, it is necessary to conduct periodic training of personnel in emergency situations with the development of practical skills.

### Conclusion

To counter emergencies and accidents located in the area of high probability of risk, response plans are developed, security barriers are proposed that prevent the situation from getting out of control. The following measures should be developed:

- Personnel action plans in case of emergency (personnel should be prepared not only theoretically, but also in practice);
- Detailed information about emergency services;
- Information on the means of communication for the transmission of information both inside and outside the enterprise;
- Evacuation routes for workers;
- List of responsible persons;
- Plans with neighboring enterprises for emergency response.

When developing measures, it is necessary to take measures aimed at reducing the likelihood of a hazardous event and its development into an emergency, and then aimed at reducing the negative consequences of the accident on the environment. It may include measures for the installation of emergency protection systems, improving the reliability of technical equipment, the clear functioning of warning systems, etc.

To determine the priority of the implementation of measures to reduce risk in the context of given funds or limited resources it is necessary:

- To determine the totality of measures that can be implemented for a given amount of funding;
- To evaluate their effectiveness;
- To rank measures by the indicator "efficiency - costs".

If non-costly measures can be proposed to counter risks, they can be implemented immediately.

The entity should periodically review the effectiveness of emergency preparedness and response procedures. This analysis must be carried out after the occurrence of an incident or after conducting exercises, if necessary, the algorithms for personnel actions are adjusted.

The development of environmental management systems at aircraft manufacturing enterprises and the implementation of the preparation stage for the possibility of emergencies and accidents will help to reduce the likelihood of industrial accidents, the direct costs of enterprises associated with the destruction of fixed assets and environmental pollution. It will reduce ecosystem damage, prevent the deterioration of the quality of natural resources, reduce biodiversity and incidence of the population. Ultimately, it will reduce the damage to the country's economy.

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