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Regulation of formalization of technosphere safety

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Annotation

A generally recognized trend of civilizational development at the present stage is a significant increase in socio-economic losses from various hazards, which are based on natural and anthropogenic processes. Most of the hazards are natural and man-made, and the increasing vulnerability of society to hazards is determined by socio-economic factors. The constant presence of natural and man-made hazards in the processes of social development allows us to assert their systematic nature and the need to take them into account when predicting social development.

The interdependence of natural and man-made security factors is now confirmed at a fundamental level. Thus, geologists have discovered a new phenomenon in the dynamics of the earth's crust, called induced or technogenic seismicity. The essence of this phenomenon is that anthropogenic impacts can lead to the formation of additional stress inside the earth's crust and become the trigger of a seismic event prepared by nature.

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Keywords

Regulation, technosphere security, formation, development.

Introduction

In recent decades, many countries have faced the effect of "synergistic" amplification of adverse factors of various nature. For example, adverse weather conditions or natural disasters lead to serious economic losses, this causes large social expenditures. This leads to the fact that society becomes even more unstable relative to accidents and catastrophes-triggered "Domino effect". All this actualizes the problem of the need to apply a systematic approach to the study of natural and man-made safety factors.

System analysis is recognized as an effective tool for the study of safety problems, in particular the problem of ensuring natural and man-made safety (PTB). The urgency of improving the system approach to solving security problems is caused by the unresolved conceptual, theoretical and methodological aspects of the analysis and comprehensive assessment of natural and man-made hazards of complex systems. At the same time, there is a contradiction between the need to analyze the state of various systems in order to prevent the occurrence of threatening situations caused by the interaction of natural and man-made factors, to improve the safety of existing and newly created enterprises, on the one hand, and the lack of adequate scientific and methodological support, on the other.

Main part

The problems of PTB are given considerable attention in scientific research both in Russia and abroad. Domestic and foreign scientists have developed theoretical and methodological foundations for qualitative and quantitative assessment of the level of PTB, methods to minimize socio-economic losses in the implementation of dangerous situations. Scientific works of leading Russian and foreign scientists are devoted to the problems of analysis and risk management of natural and anthropogenic origin.

At the same time, it should be noted that the issues of ensuring the security of social development, countering real threats to development, the formation of a new worldview on the problems of managing natural and man-made accidents and catastrophes, taking into account the complex solution of security problems, remain insufficiently studied. Systematic PTB requires the study of a set of factors, causes and conditions of hazards and the definition of their account for the strategy of further development of society.

Analysis of the results of domestic and foreign researchers indicates the need to develop theoretical and methodological principles that would ensure a systematic analysis of the factors of PTB, the construction of appropriate models of natural and anthropogenic processes that cause emergencies.

The purpose of the work is a systematic analysis of the problems of PTB, the development of conceptual approaches to improve the system approach and the construction of adequate models for the study of problems of natural and man-made safety. System-wide principles developed methodological framework for the analysis of interrelations of natural, technological and social factors of natural-technogenic safety, grounded features of a systemic approach to the study of the safety of natural and human systems.

Presentation of the main material. The security problem of any system loses its meaning if the human factor is ignored – the security problem is primarily human security. At the same time, professionalism, moral and ethical principles and values of those people who face dangerous objects play a key role in ensuring safety: from managers to employees who are on the object itself. According to world statistics, 80 % of all emergencies in the air and 70 % at sea are related to the "human" factor.

Therefore, the defining principle should be that the person is both the main object and subject of the study of problems of natural and technological safety.

The main types of natural and anthropogenic hazards include:

- natural character: floods, tsunamis, earthquakes, hurricanes, mudslides, typhoons, etc.;
- technogenic character: accidents, catastrophes, fires, explosions, etc.;
- social nature: socio-psychological dangers associated with social tension, conflict, and the like.

For modeling dangerous processes, the system model "man–machine" or the more General "social machine" system was mainly used. At the same time, it was believed that the danger factors are concentrated in the element "machine" and are released mainly because of the violation of relations with the element "man".

Such models do not always pay due attention to the natural component of the hazard that poses a serious threat to humans. In this context, today, during the consideration of the transition from purely machine-based technical and social systems, taking into account the natural environment of their functioning. What these approaches have in common is that they are based on a systematic methodology.

Features of application of system methodology concerning problems of PTB of functioning of natural and anthropogenic systems consist in the following:

- safety is interpreted as the property of the system to ensure the normal operation of its operation with minimal risk of harm;
- danger is an inevitable attribute of the functioning of any system and is considered as a possibility of transition of the system to a state in which negative structural and functional changes are possible, which can lead to its destruction;

– all real-life hazards of natural and man-made hazards can be grouped into three classes: natural, man-made and social, and each of them is caused by inadequate flows of energy, matter or information;

In comparison with other known methods of research (statistical observations and field experiments), the most important place in the system analysis of safety belongs to theoretical research by formalization and modeling of dangerous processes.

Systems as object of research of problems of PTB are complex, multilevel and multicomponent formations. In order to obtain adequate information and determine the causal relationships between the elements of the system, it is necessary to clearly specify its structure and nature of operation. This is achieved by decomposition of the system: the division of the hierarchy and organization of the system into interrelated components (subsystems, elements). First, the security factors of simpler subsystems are investigated, and then the results are grouped to obtain the characteristics of the entire system. This approach allows you to uniquely identify possible hazards and dangerous States of the system.

The effectiveness of the system approach depends on the choice of the leading subsystem or element in the decomposition of the system. If this element (subsystem) is selected unsuccessfully, then, despite the identity of the result, the calculations will be significantly cumbersome. In the case of sufficiently complex systems, the correct selection of the main elements to create a simple configuration may not be an easy task.

The difficulties that arise when considering complex systems can be reduced by using the conversion method. It consists in the sequential simplification of systems with serial and parallel connection of elements by converting them into equivalent circuits. This procedure is performed until the entire system is reduced to two or three elements or subsystems.

Modern man lives in the world of nature, technology and society. Therefore, in order to study the problems of natural and technogenic safety, we propose a model of the ecological and technogenic

system (ETS), which, in our opinion, adequately reflects the main processes that determine PTB

In General, under ETS we will understand a certain way organized society, economic objects and technosphere, as well as natural and territorial ecosystems that form a single structural and functional whole. As a rule, these systems in their spatial and other parameters correspond to the administrative and economic territorial entities of the state and can be of different levels and scales: from the National to the object. Natural, technological, social processes, objective and subjective factors interact within the ETS. Such systems are complex systems with a hierarchical structure that have the ability to adapt to changes in the operating environment.

In our opinion, the expediency of choosing ETS as an object of research of safety problems of natural and anthropogenic systems is due to the following factors:

a) the system contains both a source of danger and a potential victim (that is, the object and subject of danger: environmental, technogenic and social subsystems);

b) the functioning of the ETS adequately reflects the real natural, social and economic processes;

c) the ETS model makes it possible to use system-wide principles in the analysis of hazards, which makes it possible to predict the occurrence of dangerous situations to a certain extent.

An important factor in modeling is that the ETS is characterized by a three-level degree of its organization.

The first level is the natural environment as a set of natural and natural-anthropogenic factors that make up the metainfrastructure of modern production.

The second level is society, the population as biological and social factors that form a certain environment in which demographic, social and socio-economic phenomena occur.

The third level is the production and technological structure as a set of technological processes, material-energy and production-technical relations that are formed in the production process.

External (for a specific ETS) environment will be considered all that is not directly included in it but can affect the process of functioning or change the system, internal-a set of environments of the main subsystems.

Considering the generally accepted definitions, taking into account the purpose of the study, we will give definitions of the main subsystems of the ETS.

Social subsystem (society) - a set of groups of people United by certain relationships, due to historically variable ways of production of material and spiritual goods, a common territory of residence. During the study of the social subsystem of the ETS, in our opinion, it is necessary to take into account the position that was known in ancient times: "the Measure of all things is man", and since man is an integral part of nature and without it the existence of its life is impossible, then the priority in the relationship between nature and the technosphere belong to nature. However, in modern conditions, in most scientific research, the priority in solving scientific problems belongs to the technical and economic content – such concepts as economic efficiency, labor productivity, profitability, energy consumption, which are undoubtedly important in production, but they do not take into account the natural biosphere factor.

Today, the progress of technology is obvious, but the consequences of its use lead to the biosphere, its main components (atmosphere, hydrosphere. lithosphere) to a state that is not compatible with life. Therefore, the social subsystem occupies a special place in the processes of functioning of ETS.

Ecological subsystem (environment) – a system of abiotic and biotic natural factors that directly affect a person, his economic activity within a certain territory. The specificity of the ecological subsystem in the context of ensuring natural and technological security is that, on the one hand, it is the basis of life as an individual and society as a whole, and on the other – a source of powerful dangers

that pose a threat to the normal functioning of society as a whole.

Technogenic subsystem (technosphere) - a complex of means and methods of processing matter, energy and information for the purpose of production of a given product on a certain territory. What is common to existing technospheres is that they are an artificially created habitat to meet the needs of human society. However, in several definitions that are widely used, there is no significant addition to the fact that, despite the artificial origin and a certain feature, the technosphere is an integral part of the biosphere, without which human existence is impossible.

Therefore, the technosphere must be considered as part of the biosphere, radically transformed by man into technical and technological objects (buildings, roads, mechanisms, etc.) in order to make the best use of natural resources and meet the socio-economic needs of mankind.

We can agree with the interpretation of the technosphere as the dominance of the technical factor in the social organization. Representatives of this approach believe that environmental problems that arise as a result of anthropogenic activities are the result of irrational management and can be solved through technical reorganization, improvement of equipment and technological processes.

In General, today the technosphere is the most important part of the material technical culture of industrial civilization. This is not so much a mechanism for the transformation of nature into consumer goods, but rather the environment, transformed by anthropogenic activity into a technoprirodny territorial complex: technolandscapes. Technolandscape is a space-time environment for the functioning of complex sociotechnical systems that contain a variety of social and technical subsystems, including dangerous production facilities.

The complexity and heterogeneity of the security problem necessitates the use of modeling and formalization in the study of relevant processes within the ETS. In this case, formalization is called a specially systematized adequate representation in the form of some artificial objects (models), and under modeling – the use of objects obtained so that they have a certain similarity to the original, to obtain new knowledge about the processes under study.

One of the important goals of hazard modeling is forecasting. From the point of view of formalization and use of mathematical methods for assessing and predicting hazards, they are understood as determining the probability of occurrence of adverse events (crisis phenomena and catastrophic situations) and possible losses from them, which determine the necessary level of protection of vital interests of the individual, society and the state.

PTB is largely related to the nature of the functioning of the technosphere. The reason for the high percentage of man-made accidents and catastrophes is the violation of proportions in the “man – machine " system. Any system, including the “man – machine” system, functions effectively if the main elements of this system correspond to each other. The increase in the rate of scientific and technological progress is the growth of energy intensity of technology and technological processes, a multiple increase in information flows, while the person remains virtually unchanged: visual acuity, reaction time, memory and other psychophysiological criteria formed in the process of evolution remain unchanged.

In functional terms, the machine preferably has two States: normal operation and disruption of normal operation. A person between these States has many intermediate States: emotional tension, reduced attention, fatigue, illness, and others, which is the cause of a high percentage of accidents and catastrophes. The functioning of the man – machine system is also affected by environmental factors that cause a change in the other man-environment system.

Modern technogenic sphere has accumulated a huge potential danger that can be implemented catastrophically in the event of emergency situations at the facilities. Although man-made hazards are

more predictable, however, given the ageing process of the main equipment and reduced the capacity of personnel in the coming years is expected to increase the frequency and magnitude of consequences of failures and accidents at potentially hazardous industrial facilities.

For ecosystems and society, there are certain common algorithms, patterns and common values, according to which their functioning occurs. This is common to biota and humanity contains the following provisions:

- the existence of a single material and energy-information basis localized within space and time, in the forms of material objects;
- system structure, functions and hierarchy;
mnogoparametricheskikh, complexity, stochasticity;
- the desire to maintain an optimized and efficient existence, viability;
- preservation of a certain order, structure for significant, but characteristic of the life cycle of systems, periods of time;
- the system of life activity, allowing the dynamics, variability, mutation, transformation, the presence of innovations and self-activity (initiatives) of the whole and parts;
- self-reproduction in General and in parts, etc.;
- adaptability to conditions due to lability and self-organization, reorganization and self-development;
- the presence of phases of transition ("transition States") and the "removal" of previous forms, qualities and States in the development of a higher or lower.

Using the methodology of system analysis, we identify the most important methodological principles that must be followed when investigating ETS.

1. The principle of optimal simplicity. The solution of social, environmental and technological problems should be coordinated with the main purpose of the ETS functioning, which is determined by society. It should be based on accurate data on the structure and functioning of the ETS and be determined by the directional actions that can be used.

2. The principle of social responsibility. The recommendations of experts on the problems of functioning of the main subsystems of the ETS should contain an assessment of possible social losses for individual social groups and the risks associated with the implementation of the proposed solutions.

3. The principle of interdisciplinarity. ETS is a heterogeneous system, so it is necessary to use interdisciplinary approaches that should cover the simultaneous functioning of social, environmental and technological processes.

4. Principle of objectivity. Each ETS subsystem functions in accordance with objective laws, which are reflected in the concepts of "truth”," adequacy”, "optimality".

5. The principle of a hierarchy of goals, values, and "economic realism". Building computer models, forming a decision support system, making economic decisions, it is necessary to clearly formulate clearly represent (and, if necessary, define) the system of values and hierarchy of goals that the ETS has.

6. The principle of analysis of constantly developing systems. During the study of many phenomena, especially in the social and technogenic subsystems, the properties of the system can change significantly, which should be the subject of special attention of researchers.

7. The principle of system synthesis. In the study of the functioning of the ETS and any of its subsystems, it is necessary to identify the main parameters of the structure and processes that determine the dynamics in the time intervals determined by the purpose of the study.

According to the proposed ETS model, we will define a natural and man-made hazard: a property of the ETS that characterizes the state of the system, which causes the possibility of disruption of the

normal functioning of the ETS and the appearance of losses within each subsystem. According to the natural and technological safety of the ETS will be considered as a state of a complex system that ensures the normal functioning of the system as a whole and its individual subsystems and achieve the goals of its operation.

PTB is closely related to emergency situations (emergencies). By an ETS emergency, we will understand a significant change in the structure or nature of the functioning of the system, which causes the appearance of losses caused, as a rule, by the destructive influence of flows of energy or matter or information. The main types of emergencies within the ETS include man-made disasters, natural disasters, social disasters. Loss ETS will be interpreted as a measure or result of changes in the nature of the functioning or structure of subsystems ETS, characterized by a violation of the integrity or deterioration of other system factors that makes it difficult or impossible to perform the main purpose of the system or its individual subsystems.

For a long time, the concept of “absolute security " prevailed – it was believed that it was possible to create a safe system of any complexity. Today it has become obvious that there can be no safe systems: only “danger"is absolute. Effective management decisions require quantitative information about the level of hazards and threats and their dependence on various factors. To obtain such information, we need special tools (methods, models, methods, algorithms), which makes it possible to form an appropriate decision support system in the field of forecasting and minimizing the consequences of natural and man-made emergencies.

Conclusion

Even though the problem of safety in the scientific literature has been considered quite often, today there are almost no studies devoted to the specifics of using a systematic approach in the formation of mechanisms for managing natural and man-made safety. Therefore, the problem of developing theoretical bases of natural and technogenic safety management based on a system approach is urgent. Special attention should be paid to the development of risk - based analysis of the consequences of emergency situations and the definition of integrated criteria for assessing the level of natural and man-made safety; improvement of the mechanism of state regulation and forms of management in this area.

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Регулирование формализации обеспечения техносферной безопасности

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Аннотация

Общепризнанной тенденцией цивилизационного развития на современном этапе является значительное увеличение социально-экономических потерь от различных опасностей, которые основаны на естественных и антропогенных процессах. Большинство опасностей являются природными и антропогенными, а растущая уязвимость общества к опасностям определяется социально-экономическими факторами. Постоянное присутствие природных и техногенных угроз в процессах общественного развития позволяет нам утверждать их системный характер и необходимость учитывать их при прогнозировании социального развития.

Взаимозависимость природных и искусственных факторов безопасности в настоящее время подтверждается на фундаментальном уровне. Таким образом, геологи обнаружили новое явление в динамике земной коры, называемое индуцированной или техногенной сейсмичностью. Суть этого явления заключается в том, что антропогенные воздействия могут привести к образованию дополнительного напряжения внутри земной коры и стать спусковым механизмом подготовленного природой сейсмического события.

Для цитирования в научных исследованиях

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Ключевые слова

Регулирование, техносферная безопасность, формирование, развитие.

Библиография

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