Regulation of risks with accounting for the possibility of terrorist attacks on critical infrastructure facilities

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Abstract. An important task of critical infrastructures is ensuring stable functioning of the objects of increased danger which are their part. For increase in safety of critical infrastructures and minimization of consequences from the possible emergency situations initiated by accidents and catastrophes needs to improve methods of assessment and regulation of risks connected with functioning of hazardous facilities, and especially critical facilities at various stages of their life cycle. For practical use the risk-based approach in regulation risks of functioning of critical facilities (CF) in the face of terrorist threats, it is necessary first of all to define the criteria and acceptable levels of risk. The article deals with the state of the system of risk regulation in the Russian Federation in the relevant subject area.

1. Introduction
At the first stage of regulation of risks in the Russian Federation, when assessing the protection of functioning of facilities and territories from emergency situations of various nature the basic concept that determines their safety was acceptable risk, and for regulation of risks used the system of risks, including unacceptable (inadmissible), maximum permissible, admissible, increased, conditionally acceptable, and acceptable risk.

Later, when regulating and managing risks of emergency situations, the range of risks was broken into three areas: zones of unacceptable (excessive), acceptable and negligible risk were allocated. State of protection of objects and territories from emergencies was assessed depending on in what of three areas of the risk level were received results.

At the present stage the range of risks of emergencies (regarding its probabilistic component) breaks into two areas: acceptable and unacceptable risk [1]. So, according to state standard GOST P 51898-2002, assessment of risk – the procedure of check based on results of risk analysis, defining whether the acceptable risk is exceeded.

2. Regulation of acceptable risk of emergency situation
Risk can be assessed for the considered territory or an object, its parts, separate projects, activity, a specific hazardous event. Therefore, in various situations various indicators and methods of risk assessment can be applied. In the regulatory-legal literature differ:

- acceptable risk of emergency situation – risk which is acceptable and reasonable for social and economic development of the considered territory;
acceptable risk of an accident – the values of the risk of an accident at a hazardous production facility established or obtained according to a formalized established procedure, which excess characterizes threat of emergence of accident;

• acceptable risk of functioning of technical means and systems at various stages of their life cycle defined as residual risk owing to impossibility to consider and exclude all factors reducing safety because of their accidental and objective nature.

When assessing terrorist risks for CF the concept of acceptable risk of emergency is used. At the same time it is necessary to consider that the immediate goal and the most likely consequence of a terrorist act is an accident at the facility. Therefore, when analyzing terrorist risks, it is advisable to use the currently well-developed regulatory and methodical base for assessment of risk of accidents.

Indicators and methods for calculating the acceptable risk of designing and operating technical means and systems it is advisable to use in assessing the acceptable risk of the functioning of their components, in particular the critical elements of the CF, paying at the same time special attention to justification of safety factors on risks.

The concept of acceptable risk of emergency situation is key for assessment of a state of protection of the population of territorial subjects of the Russian Federation against emergency situations of natural, technogenic and biologo-social character; therefore the main terms, definitions and quantitative values of acceptable risk of emergency are highlighted in a separate state standard – GOST P 22.10.02-2016. Its provisions are intended for use by:

• federal executive authorities and their territorial bodies;

• executive authorities of the constituent entities of the Russian Federation and by local governments;

• research and design organizations and organizations operating potentially hazardous and critical facilities (italics our), defined as such in accordance with the legislation of the Russian Federation.

At establishment of acceptable risk of emergency situations it is necessary to use the following quantitative indices of risk of emergency situation:

• individual risk of emergency;

• social risk of emergency.

Currently, the acceptable individual risk of emergency situations has been established for each subject of the Russian Federation on the basis of statistical data on emergency situations that occurred on the territory of the subjects of the Russian Federation from 1992 to 2014, including technogenic, natural, biologo-social emergencies, technogenic fires and terrorist acts (italics our). For example, the acceptable individual risk for the Sakhalin region is $1.75 \times 10^{-4}$ year$^{-1}$, for the Murmansk region – $9.07 \times 10^{-6}$ year$^{-1}$, for the Sverdlovsk region – $1.23 \times 10^{-5}$ year$^{-1}$, for Moscow – $6.42 \times 10^{-6}$ year$^{-1}$.

The acceptable social risk of emergency situations, established for each subject of the Russian Federation, is $10^{-5}$ year$^{-1}$. At the same time, the social risk of emergency situations is considered unacceptable if it is more than 10 times higher than the acceptable social risk of emergency situations.

3. Assessment of acceptable terrorist risk of emergency

The subject of the Russian Federation is a large territorial entity, including construction, industrial and agricultural enterprises, infrastructure facilities and the social sphere, legislative and executive management bodies and other objects. As GOST P 22.10.02-2016 defines acceptable values of risk indicators for the territorial subject of the Russian Federation in general, in relation to separate CF as an elements of critical infrastructure two tasks are relevant:

• determination of acceptable risk of emergency for the concrete CF which is in this given territory;

• selection of the «share» falling on acceptable terrorist risk from all sources of emergency situation.

The solution of the first task depends on at what stage of life cycle there is this given object. If CF is at a stage of operation, reconstruction or technical re-equipment, it must have an approved safety
passport of the facility and emergency risk assessment calculations with a detailed justification, including the calculation of individual and social risk indicators. If the calculated risk levels are lower or equal to the established ones, it is concluded that, judging by these indicators, the CF does not require the adoption of special additional measures for strengthening of its safety (the same applies to other regulated types of risk). Otherwise, in accordance with the established procedures, development (correction) of measures to reduce the risk of an emergency is carried out.

At the stage of justifying investments, designing, preparing technical documentation, as well as manufacturing and commissioning in a given territory when determining acceptable individual and social risks of concrete CF it is necessary to proceed from the fact that their actual levels shouldn't be higher than those established by GOST P 22.10.02-2016.

At the solution of the second task it is necessary to consider that sources of the potential increased danger to any CF, along with terrorist threats, are such classes of threats as natural, biologo-social, technogenic, ecological, professional, informational, economic, cyberdangers and other their possible types and combinations. Acceptable individual and social risks for an object are integrated criteria which are determined to a specific CF with its inherent vulnerabilities when exposed to all significant external and internal factors, including various hazards and threats. The approximate scheme of achievement of acceptable risk is shown in Figure 1.

![Figure 1. Scheme to achieve acceptable risk.](image)

Values of parameters of acceptable terrorist risk, as well as other types of risks that a concrete object is exposed to, can be obtained by solving the «inverse problem»: the target value of individual and social risk is known; it is necessary on the basis of formulated risk-model of an object to determine the parameters corresponding to the given criteria.
So, the individual risk of emergency can be represented as a function defined on the surface adjacent to hazardous facility [2]:

\[ R_i(x, y) = \sum_{i,j} \lambda_i E_{ij}(x, y)P_j \]  

(1)

where \( \lambda_i \) – the frequency of realization of the \( i \)-th scenario; \( E_{ij}(x, y) \) – the probability of realization of the \( j \)-th impact mechanism at the point \((x, y)\) for the \( i \)-th scenario; \( P_j \) – the probability of damage during realization of the \( j \)-th impact mechanism.

The numerical value of \( R_i(x, y) \) for solving the «inverse problem» is determined from GOST Р 22.10.02-2016.

Social risk can be, for example, determined by a calculation method according to the data on equipment operating time at hazardous industrial facilities of the study territory and the number of the people getting to zones of possible damage [3]:

\[ F = k \frac{T}{N} 10^{-4} \]  

(2)

where \( F \) – the frequency of death of 10 and more people (\( F = 10^{-5} \text{ year}^{-1} \)); \( T \) – the actual average operating time of hazardous equipment; \( k \) – the empirical coefficient of weight of threat (\( k = 0.05 \) at threat to society; \( k = 0.5 \) at threat to personnel); \( N \) – the number of people getting to the affected zone.

The choice of calculated model, allowing, based on the target values of individual and social risks, to determine their acceptable parameters for concrete CF, in each case is determined by specifics of the considered object.

4. Main recommended quantitative indicators of emergencies risk

Besides individual and social risk of emergency situation of the key quantitative indicators of risk of emergency usually are included:

- collective risk of emergency, defined as the mathematical expectation of the death toll as a result of possible impact of all set of damaging factors of sources of emergency situation in the considered territory in a year;
- potential territorial risk of emergency defined as emergence probability in a year in the considered territory of all set of the damaging factors of sources of possible emergency situation with the level which can lead to death of people and to causing material losses;
- economic (variant – material) risk of emergency, defined as the mathematical expectation of the random value of material losses from an emergency situation in the considered territory for a year (variant – for a certain period of time).

When listing the main quantitative indicators of risk of emergency, it is also necessary to single out indicators of technical and environmental risk. Being components of more general characteristics of risk (collective, potential territorial or economic), they have independent significance, extensive literature is devoted to their identification, assessment, and methods of decrease.

According to problems of risk analysis besides the main additional indicators of risk can be applied. So, additional indicators of risk of accident on hazardous production facilities are presented in «Methodical bases on carrying out the analysis of dangers and assessment of risk of accidents on hazardous production facilities» [4].

Practical use of the listed indicators for risk-analysis and the implementation of risk management measures implies the existence of their normative (criterial, acceptable) values.

It is necessary to note the difference in approaches to regulation of a probabilistic and material component of risk (defined as a measure of the danger of emergency situation, combining the probability of emergency and its consequences (losses)).
5. Categorization of objects – rationing of interval values of safety
The extent of losses from an emergency is currently used at categorization (classification) of emergency situations in relation to objects of increased danger.

Example is the classification of emergency of natural and technogenic character by scales accepted by the Resolution of the Government of the Russian Federation of May 21, 2007 No. 304 «About classification of emergency situations of natural and technogenic character».

For determination of category (class) of danger of an object risk matrixes (of threats, of vulnerability) with use of methods of fuzzy logic are formed. Then, on the basis of the calculations made, the category (class) of danger of the object or territory under consideration is determined for different types of emergencies and the necessary measures to manage the identified risks are determined.

Fuzzy methods open up the possibility of using linguistic and scoring variables characterizing the remote consequences of an emergency when compiling matrixes of risk.

Risk matrixes in coordinates «frequency (probability) of refusal – weight of consequences of refusals», «frequency (probability) of an event – material losses» and others are for practical purposes also used [5]. Thus, the indicators characterizing a probabilistic component of risk of emergency are applied to categorization of objects and territories in relation to emergency of various character.

Methodologically matrixes of risk represent set of the interval norms determined by the amount of losses, the concrete region, a time interval (in case of use of probabilistic or frequency characteristics) and other indicators.

Categorization of objects of the increased danger in fact is rationing of interval values of safety, and determination of acceptable values of a probabilistic component of risk is point (limit, boundary, extreme) rationing. Therefore, for example, when developing problems of categorizing objects and territories in applying to emergencies, it is necessary to take into account used in rationing methods for determining the limits of rationing scales of classification signs, choosing the price of dividing for uniform scale, or of multivalued measure of these signs, and for non-uniform scale – for estimating the minimum and maximum price of division.

In a number of cases, special techniques for analysis them are developed to assess risks emergencies. For example, when assessing the key risks of financing terrorism in the Russian Federation the rating system of assessment where risks are considered as function of three factors is applied: threats, vulnerabilities and consequences. For assessment and management of risk three groups of risks are allocated: of high, average and low level. Based on the allocated groups of risks the priority (sequence assessment) of taking measures to management of risk in the relation to time is defined. For the identified high-level risks, it is necessary to take measures to minimize them in the shortest possible time; the group of risks of the average level needs to be controlled and if necessary to take the constraining measures; and in relation to risks of low level it is necessary to begin work on their minimization.

6. Current state of a system of regulation risks emergency. Conclusions
Currently, in the practice of analysis, regulation, and managing risks of emergencies use:

- point (limit, boundary) rationing for indicators characterizing probabilistic component of risk;
- interval rationing for assessment of consequences of emergency situation, applying as one of the main classification signs an indicator of the extent of losses from emergency situation;
- various additional indicators and original techniques of risk assessment, considering specifics of the studied phenomena, objects and territories.

The existing system of regulation risks from emergency is not fully formed and further, from our point of view, will develop in several directions:

- the main will be the interval multiparameter rationing of risks from emergencies. Base for its development is the available reserve in the field of classification and categorization of objects of increased danger. When developing interval norms methods of fuzzy logic, economical and statistical methods, general provisions of the theory and practice of rationing will be used;
• point (limit) rationing of individual quantitative indicators of risks from an emergency will retain its value. Concrete values and range of acceptable risks, apparently, will be periodically updated according to the international standards and rules and also specifics of the concrete temporary period, the considered look or area of emergence of possible risks;
• in some cases for assessment and regulation of risks special techniques will be used. Their application should not contradict the existing regulatory-legal documents.

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