Technological process of rescue operations in conditions of mass destruction. System-integrative aspect and principles of organization

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Abstract. In the presented article, the author substantiates the feasibility of using the "process approach" in organizing emergency rescue operations in the conditions of destroyed buildings and structures. It is noted that the advantage of the process approach is that it can be used when considering various solutions to typical organizational and technological problems and predicting the processes of emergency rescue operations ERO. The author emphasizes that the process of conducting the ERO should be considered as a complex hierarchical multicomponent dynamic system, the levels of which are characterized by diverse coordinating relationships and a certain subordination. Taking into account this circumstance, new principles of organizing the production process of ERO in the conditions of mass destruction are justified. Of practical importance is the possibility of applying these principles in the development of methodological approaches to optimizing emergency rescue operations ERO processes, substantiating rational technologies for their implementation. In General, the article presents a new, original approach to the organization and conduct of rescue operations, based on the account of organizational and technological features of large-scale emergencies and the results of the study of the system-integrative aspect.

1. Introduction
The symbol of the contradictory development and global transition of the human community to the realities of the 21st century is social unrest, political and economic crises, natural disasters, industrial accidents and catastrophes that result in emergency situations. The most serious consequences, significant material and human losses are emergency situations associated with the destruction of buildings.

Successful rescue of people under these circumstances depends on the effective implementation of emergency rescue operations (ERO), the peculiarity of which is that they are carried out mainly in extremely unfavorable external conditions, in a short time, with high intensity and the involvement of significant forces and means.

2. Relevance, scientific significance of the issue with a brief review of the literature
The effectiveness of ERO, as the experience of their implementation indicates, largely depends on the organization of management and the technologies that used. This fact is recognized by specialists in rescue business, as well as the fact that one of the ways to increase the effectiveness of the ERO is to improve management, the use of rational schemes for organizing work and technologies for their implementation.

The analysis of the conducted research as a whole showed that to date, certain management issues have been resolved, as well as the development, definition, selection and application of rational technology and the organization of the rescue operations implementation in the conditions of destroyed buildings.

In particular, in [1,2] d.t.s. Burdakov N.I., Chernichko N.I. for the first time the stages of the process of liquidation of accidents and catastrophes are described, their exhaustive characteristics are given based on the analysis of the experience of liquidation of the consequences of the devastating earthquake, the goals, objectives, terms and types of work performed at each stage are substantiated. The general laws and general rules for the organization of automated control systems and automatic control systems in disaster zones caused by large human induced and natural disasters have been established.

In [3,4,5] Doctor of Technical Sciences Bratkov A.A. special attention was paid to the development of a universal approach to the organization of work, taking into account the specifics of the situation, the peculiarities of the impact of damaging factors, a description of the technological stages and types of work, rational methods of rescuing victims, the organization of managing the actions of forces and means and their comprehensive support.

In [6] Doctor of Technical Sciences Odintsov L.G. presents the current features of the application of promising and working technologies across the entire spectrum of possible emergencies, under various conditions of the emergency environment, in relation to different objects of the rescue operations and organizational and technological conditions of the situation.

At the same time, the above works did not consider the issue of how to take into account the technological and organizational features and how to choose the technology for carrying out work at various stages of emergency response, the levels of territorial division of the disaster zone and the stages of the rescue operations.

3. Formulation of the problem

Previously At the same time, when substantiating a rational technology for the implementation of ERO, the features of their organization is conducted (time limits, state of the emergency environment, territorial division of the emergency zone, changes in the intensity of work depending on the volume of their implementation, differences in the complexity of the stages of technological ERO process, etc.).

As the analysis showed, in order to take into account these features, it is necessary to regulate the ERO processes at the stages of the work, taking into account the territorial division of the emergency zone, the amount of work ahead and the standard technologies used.

Such regulation is ensured by the application of the “process approach” in organizing emergency rescue operations based on the formalization and technological design of ERO. In the course of the rescue of victims in the conditions of destroyed buildings and structures, the interaction of rescuers, objects of work, used technical means and the environment [3].

In this regard, it is advisable to get acquainted in more detail with the specifics of this "process approach".

4. Theoretical part

It has been established that the ERO process is a set of interconnected operations or work carried out to achieve a specific result – saving the maximum possible number of victims [4].
The necessity of organizing the process is due to the fact that through its parameters (time \( t \), intensity (pace) \( J \), rate of deceleration of the intensity \( W(t) \), volume of work performed \( V \)), the degree of influence of environmental factors on the efficiency of the performance of ERO can be quantitatively expressed [4,5].

The production process of ERO has its own laws and is divided into stages. Moreover, each stage involves the implementation of the necessary types of work that are implemented through the methods of their production [1,4,5].

Studies of the ERO process, the definition and selection of a rational technology for performing these works are impossible without reference to a specific territory.

For a large-scale emergency zone, as experience shows, structural-hierarchical division is characteristic. It unites the sectors of work, that in turn, are divided into sections, and the latter have in their composition objects on which jobs are allocated [1,7].

Workplace – a limited area or site on which the ERO technological process is carried out. ERO management facilities – destroyed (damaged) buildings or the territory on which the ERO production process is organized and carried out.

In relation to the indicated territorial levels, options for technology and organization of conducting ERO are considered. In this case, the establishment of rational ones among them can be carried out only for a fairly accurately defined amount of work.

For the convenience of performing calculations when determining performance indicators, the total workloads are divided into unit volumes (meters), depending on their installed type [4]. A unit volume (meter) is understood as the amount of work necessary to complete or a completed cycle of technological operations organized at a separate workplace (site) of a typical technological process. The volume of work characterizes the state of territorial levels.

It should be noted that the rationality of the technology for the performance of ERO is evaluated in relation to specific units of rescuers. However, each unit has structural units and, in turn, may itself be part of a unit of a higher level. Each type corresponds to its own technology, territorial level, and a certain amount of work, but for the convenience of planning ERO, combinations of these components can change.

4.1. System-integrative aspect of the emergency rescue process

Taking into account the above features of the organization of victims rescue, as well as the specifics of determining the rational technology for the performance of ERO, it is obvious that the process of carrying out these works should be considered as a complex hierarchical, implemented in a multicomponent system, the levels of which are characterized by diverse coordinating relationships and a certain subordination. Graphically, the ERO process can be represented in the form of the G. Kron pyramidal network [8], in which the levels of components are interconnected both horizontally (at one level of the hierarchy – coordination) and vertically (at different levels of the hierarchy - subordination). This reflects the multidimensionality of the representation of reality.

This system includes two subsystems: "Rescue forces, means and technologies" and «Emergency environment». In addition, this system should be considered as a combination of four interconnected structures having a hierarchical structure:

- territorial;
- technological;
- organizational and staffing;
- volumetric type.

Each of them is distinguished by the constituent internal levels contain lower-order levels, but it themselves are part of the upper level. Moreover, the levels of each structure, as a rule, have similarities in the particularities of solving organizational and technological problems.

Based on the accounting features of the ERO and, in particular, the interaction and interconnection of the "participants" in this process, it seems possible to determine the list and sequence of solving
typical organizational and technological problems. The establishment of rational solutions to these problems and their subsequent implementation allow the development and optimization of the ERO process. At the same time, ERO processes for individual jobs, facilities, sections, sectors and the emergency zone as a whole can be developed and interconnected.

These tasks include [9,10]:

- selection and justification of a rational way to perform ERO;
- assessment of work intensity, capabilities of emergency rescue units, its workload, and determination of the rational type (structure) of the unit;
- assessment of the complexity and dynamics of the ERO process – the correspondence of the intensity (pace) of salvation to the victims and the presentation of jobs (sites) for service;
- identification of needs in emergency rescue units of the selected type;
- setting priorities in the organization of work and the priority of servicing jobs (sites);
- distribution of units by place of work.

The advantage of this approach is the possibility of its use in planning and technological design, i.e. the possibility of considering various options for solving typical organizational and technological problems and predicting various options for the «development» of ERO processes.

4.2. The basic principles of the organization of the production process of rescue operations in conditions of mass destruction

Based on the establishment and analysis of the hierarchical structure of the ERO process in the complex dynamics of its development, taking into account the features of typical technologies, time limits, the state of the emergency environment, the location (accessibility) of victims, the territorial division of the emergency zone, changes in the intensity (pace) of work, the urgency of their implementation, differences in the complexity of the stages of the technological process substantiated the principles of the organization of the production process of ERO in conditions of mass destruction.

It is established that the organization of the implementation of the ERO should be carried out on the following principles:

- the principle of flexible response to emergency situations;
- principle of hierarchy parity of the ERO process;
- the principle of «feedback» between technology and the organization of rescue operations;
- the principle of optimizing the states of the «participants» in the emergency rescue process.

The indicated principles of organizing the production process for rescue of victims in the conditions of mass destruction take into account the unequal state of the objects of work and victims, the genesis and the system-integrative aspect, the hierarchy of structures of the ERO process in the complex dynamics of its development, typical technologies, complexity, urgency and safety of work, intensity of their implementation.

As a result of the analysis of the system-integrative aspect of the ERO process, guided by these principles, methodological approaches to optimizing the ERO processes, justifying their rational technologies and organization can be developed.

Improving the efficiency of emergency rescue operations can also be ensured by organizing and / or developing (formalizing, regulating) ERO processes taking into account the territorial division of the emergency zone, selected technology and the scope of future work, since only in this case it is possible to take into account the influence of environmental factors on the results of the work. Formalization and regulation are provided by a phased hierarchical decomposition, modeling and optimization of the ERO process, as well as its technological design - the development and presentation to users in real time of standard technological maps, maps of the production processes of the ERO, as well as maps of their management processes.

Organization (formalization (regulation and technological design)) of the ERO process includes:
the establishment of rational production and technological methods and techniques for the implementation of ERO;

development, as a result of the optimization of the ERO process, of rational solutions to typical organizational and technological problems and activities aimed at their implementation.

Optimization of the ERO process consists in finding the optimal values of the parameters of the ERO process and determining or choosing rational organizational and technological solutions on this basis.

At the final stage of the organization of the ERO, a set of practical measures is carried out aimed at implementing solutions to typical organizational and technological problems.

ERO: the main provisions of the organization and/or development (formalization (regulation and technological design)):

- accounting for the territorial division of emergency zones and the organizational and staff structure of emergency rescue units [1,4,7,10];
- the use of typical unit measurements (meters) of work [4];
- taking into account the structure of the ERO process, dividing the emergency rescue process into stages, types and methods of work [1,3-5,9,10];
- taking into account the influence of the complexity factor on the intensity of the ERO process [4,5,10,11];
- accounting for changes in the state of the emergency [4]
- ERO allows, on the one hand, assessing the needs for technical equipment and rescue specialists, and on the other hand, creating opportunities for emergency rescue units and predicting the duration of ERO processes.

As a result, a rational technology for the execution of work and a definitely rational scheme for their organization can be chosen.

Based on the accounting features of the ERO and, in particular, the interaction and interconnection of the «participants» in this process, it seems possible to determine the list and sequence of solving typical organizational and technological problems. The establishment of rational solutions to these problems and their subsequent implementation allow the development and optimization of the ERO process. At the same time, ERO processes for individual jobs, facilities, sections, sectors and the emergency zone as a whole can be developed and interconnected.

5. Practical significance, proposals and results of implementations, results of experimental studies

The practical significance of the presented research results lies in the possibility of their use when planning measures to eliminate natural and human-induced emergencies, in particular, when organizing an emergency response system, as well as when training specialists - rescuers and persons who make managerial decisions when conducting large-scale emergency rescue operations.

One of the promising directions for the implementation of the results obtained is their use in the creation of decision support systems [12,13] and virtual training complexes [14-16], designed to develop technologies for the prevention and elimination of emergencies, in which promising technological platforms and tools are set forth in [12,14,15,17-20].

The following findings:

1. During the rescue of victims in the conditions of destroyed buildings and structures, there is an interaction of rescuers, rescued, objects of work, the use of technical means and the environment. This interaction is a process that has its own laws. Moreover, each stage involves the implementation of the necessary types of work.

2. On the basis of accounting for the implementation of tasks related to ERO and, in particular, the interaction and interaction of the "participants" in this process, it is possible to determine the list and sequence of solutions to typical organizational and technological problems.
The introduction of rational solutions to organizational and technological problems and their subsequent implementation ensure the implementation and optimization of the ERO process. ERO for individual jobs, facilities, sections and emergency zones in general.

3. It has been established that the process of carrying out ERO should take into account both a complex hierarchical multicomponent dynamic system and the level of its interaction with certain subordinations.

4. Based on the establishment and analysis of the hierarchical structure of the ERO process in the complex dynamics of its development, taking into account the features of standard technologies, time limits, the state of the emergency environment, the location (accessibility) of victims, the territorial division of the emergency zone, changes in the intensity (pace) of work, their urgency implementation, differences in the complexity of the stages of the technological process substantiated the principles of the organization of the production process of ERO in conditions of mass destruction.

It is established that the organization of the implementation of the ERO should be carried out on the following principles:

- the principle of flexible response to emergency situations;
- principle of "hierarchy parity" of the ERO process;
- the principle of "feedback" between technology and the organization of rescue operations;
- the principle of optimizing the states of the “participants” in the emergency rescue process.

The indicated principles of organizing the production process for rescue of victims in the conditions of mass destruction take into account the unequal state of the objects of work and victims, the genesis and the system-integrative aspect, the hierarchy of structures of the ERO process in the complex dynamics of its development, typical technologies, complexity, urgency and safety of work, intensity (pace) their implementation.

As a result of the analysis of the system-integrative aspect of the ERO process, guided by these principles, methodological approaches to optimizing the ERO processes, justifying their rational technologies and organization can be developed.

5. Improving the efficiency of emergency rescue operations can be ensured by organizing and/or developing (formalizing, regulating) ERO processes taking into account the territorial division of the emergency zone, selected technology and the amount of work ahead, since only in this case it is possible to take into account the influence of factors situation on the results of the work. Formalization and regulation are provided by a phased hierarchical decomposition, modeling and optimization of the ERO process, as well as its technological design – development and presentation to users in real time of standard technological maps, maps of industrial processes of the ERO, as well as maps of their management processes.

The advantage of this approach lies in the possibility of its use in planning and technological design, that is, in the possibility of considering various options for solving typical organizational and technological problems and predicting various options for the «development» of ERO processes.

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