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ORGANIZATION OF EMERGENCY RESCUE AND OTHER URGENT WORKS IN RAILWAY TRANSPORT

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ABSTRACT
This article discusses the organization of emergency rescue and other urgent works during natural and man-made emergencies occurring at railway transport facilities. The specific features of rescue operations during railway accidents, fires, and incidents involving dangerous goods are analyzed. Particular attention is paid to the interaction between civil protection units, railway services, and specialized rescue and recovery trains. The methods of conducting rescue operations under radiation and chemical hazard conditions are also scientifically substantiated.
KEYWORDS: *Railway Transport, Emergency Rescue Operations, Emergency Situation, Dangerous Goods, Civil Protection.*

At present, railway transport plays a crucial strategic role in the economy of our country and holds one of the leading positions in the transportation of goods and passengers. The steady increase in railway transportation volumes requires continuous technical improvement of this mode of transport, ensuring traffic safety, as well as enhancing systems for the prevention of emergencies and mitigation of their consequences.

In particular, under conditions of natural and man-made emergencies, the timely and effective organization of rescue and other urgent operations at railway transport facilities remains one of the most pressing issues.

Emergencies occurring in railway transport are mainly caused by train derailments, collisions, fires, explosions, spills of hazardous materials, as well as natural disasters. Such incidents can cause serious damage not only to transport infrastructure but also to human life and health, as well as to the environment. Therefore, promptly eliminating the consequences of emergencies, providing rapid assistance to victims, and restoring railway operations as quickly as possible are considered essential tasks.

An emergency is characterized as a situation within a specific area that may lead to human casualties, harm to health and the environment, and significant material losses, caused by accidents, disasters, natural hazards, or other dangerous events. In railway transport, such situations mainly arise due to technical failures, human factors, external natural influences, and violations of regulations for the transportation of hazardous materials.

Rescue operations are a set of primary measures carried out during emergencies aimed at saving people, providing first aid to victims, eliminating sources of danger, and stabilizing the situation. Along with these activities, other urgent works are performed to create the necessary conditions for the safe and effective implementation of rescue operations, restore engineering and communication systems, and prevent secondary emergencies.

In railway transport, the effectiveness of emergency response and rescue operations is assessed based on the following factors:

$$S = \frac{K \cdot R}{T} (1)$$

In this context:

S – overall efficiency indicator of rescue operations;
K – number of rescue units involved;
R – readiness level of equipment and special tools ($0 < R \leq 1$);
T – emergency response time (hours).

Practical Example:

- K = 5 units
- R = 0,8
- T = 2 hours

$$S = \frac{5 \cdot 0,8}{2} = 2,0 \ (2)$$

This result indicates that as response time decreases, the effectiveness of rescue operations increases.
The organization of rescue and other urgent operations in railway transport has its own specific complexities. These are обусловед by the presence of a large number of wagons concentrated in one area, the presence of passengers, and the transportation of explosive, flammable, chemical, and radioactive hazardous materials. In addition, working in electrified sections, limited access routes, and a high risk of fire further complicate rescue operations.

Therefore, in eliminating emergencies in railway transport, it is essential to ensure close cooperation between civil protection structures, railway transport services, fire-rescue units, as well as specialized rescue and recovery trains. Scientifically grounded planning of rescue operations, the use of modern equipment and technologies, and improving the professional training of personnel play a crucial role in reducing the consequences of emergencies.

Theoretical Foundations of Emergencies and Rescue Operations

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Emergencies are among the factors that pose serious threats to human safety, production stability, and environmental conditions in modern society. Railway transport facilities are classified as high-risk sources, as they involve the transportation of large volumes of cargo and passengers, including explosive, flammable, toxic, and radioactive substances. Therefore, the likelihood of emergencies in railway transport is relatively high, and their prevention and mitigation require a scientifically grounded approach.

An emergency is understood as a situation within a specific area that may result in human casualties, harm to health, environmental damage, and significant material losses. In railway transport, emergencies are classified according to their origin into natural and man-made types. Natural emergencies include earthquakes, mudflows, landslides, floods, and severe weather events. Man-made emergencies are associated with train derailments, collisions, fires, explosions, and the leakage or spread of hazardous materials.

Accidents in railway transport are often caused by technical failures, wear and tear of tracks and rolling stock, disruptions in signaling and communication systems, human factors, and violations of transportation regulations. In particular, accidents involving the transportation of hazardous materials represent one of the most severe forms of emergencies, as they can cause damage over large areas. Therefore, it is important to thoroughly analyze the causes of emergencies and develop effective preventive measures.

Rescue operations are one of the main types of activities aimed at eliminating the consequences of emergencies. The primary objectives of these operations are to save lives, provide first aid to victims, limit or eliminate sources of danger, and prevent secondary emergencies. Rescue operations are always carried out under conditions of limited time, high risk, and intense psychological pressure, which requires precise planning and strict management.

Statistics

Statistical data play an important role in analyzing emergencies and improving the effectiveness of rescue operations. They allow for the identification of the main causes of accidents, assessment of response efficiency, and development of measures to prevent future incidents. Analysis of statistical indicators in railway transport shows that timely response, modern technical equipment, and well-trained personnel significantly reduce the scale of damage and the number of casualties.

1. Distribution of Accident Types (for example)

Type of Accident	Share (%)
Technical failures	32%
Derailments	25%
Signaling/communication system failures	18%
Human factor	15%
Incidents involving hazardous materials	10%

Note: The above distribution is a hypothetical example based on statistical data from railway transport for the period 2021–2025.

Accident Type Distribution Diagram

The diagram is presented with accident types on the horizontal axis and percentage values on the vertical axis. This graph clearly illustrates which factors most significantly contribute to emergencies in railway transport.

To determine the probability of railway accidents, the following theoretical approach based on statistical modeling can be applied:

$$P(A) = \frac{\sum_{i=1}^{n} Ni}{T} (3)$$

In this context:

P(A) – probability of an accident;
Ni – annual number of i-type accidents;
T- total number of observation years.
Example:
If the total number of accidents over a period of 5 years is 250:

$$P(A) = \frac{250}{5} = 50\ accidents/year$$

This indicates that, on average, about 50 emergency railway accidents occur annually.

Alongside rescue operations, other urgent works are also carried out. These activities are aimed at creating the necessary conditions for the effective implementation of rescue operations. They include restoring engineering and communication systems, localizing fires, reinforcing structures at risk of collapse, and temporarily or permanently restoring electricity, water supply, and communication networks.

From a theoretical perspective, rescue operations and other urgent works are closely interconnected, and their effectiveness directly depends on coordinated management. When organizing these activities in railway transport, it is necessary to take into account the characteristics of the area, the type of cargo, the condition of rolling stock, weather conditions, and the scale of the emergency. At the same time, the technical equipment of rescue units, the professional training of personnel, and their ability to make rapid decisions are decisive factors.

One of the key theoretical principles of organizing rescue operations is their continuity and phased implementation. Initially, the emergency area is surveyed, the level of risk is assessed, and priority tasks are determined. At the next stage, efforts are focused on rescuing people and limiting sources of danger. In the final stage, recovery operations are carried out, and railway traffic is restored.

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Thus, a deep understanding of the theoretical foundations of emergencies and rescue operations makes it possible to ensure safety in railway transport, reduce human casualties, and minimize material damage. These theoretical approaches are further analyzed in subsequent sections and substantiated with real-life emergency examples.

Practical Aspects of Organizing Rescue Operations in Railway Transport

The organization of rescue operations in railway transport depends on the type, scale, location of the emergency, and the nature of hazard sources. In practice, such operations are carried out on the basis of strict management, precise planning, and close coordination between various services. In emergency situations at railway transport facilities, primary attention is given to protecting human life and health, as well as restoring traffic safety.

The initial stage of rescue operations involves receiving information about the emergency and assessing the situation. At this stage, the exact coordinates of the incident, the type of emergency, the number of passengers and staff, and the presence of hazardous materials are determined. Based on the obtained data, decisions are made regarding the deployment of rescue forces and resources, including dispatching specialized rescue and recovery trains.

The next stage involves deploying rescue units to the emergency site and conducting reconnaissance operations. During reconnaissance, risks such as fire, explosion, radiation, or chemical contamination are assessed, and potential locations of affected individuals are identified. This stage is one of the most critical in determining the effectiveness of rescue operations.

The main content of rescue operations includes searching for victims, extracting them from debris, damaged wagons, or buildings, providing first aid, and evacuating them to safe areas. At the same time, measures are taken to localize and extinguish fires, reduce explosion risks, and contain the spread of hazardous materials. In electrified railway sections, it is mandatory to disconnect power supply and ensure safety measures before starting operations.

Other urgent works constitute an important set of supportive measures for rescue operations. These include establishing temporary access roads and passages, restoring communication, electricity, and water supply systems, and reinforcing structures at risk of collapse. In order to restore railway traffic as quickly as possible, recovery trains are used to repair tracks, rolling stock, and infrastructure elements.

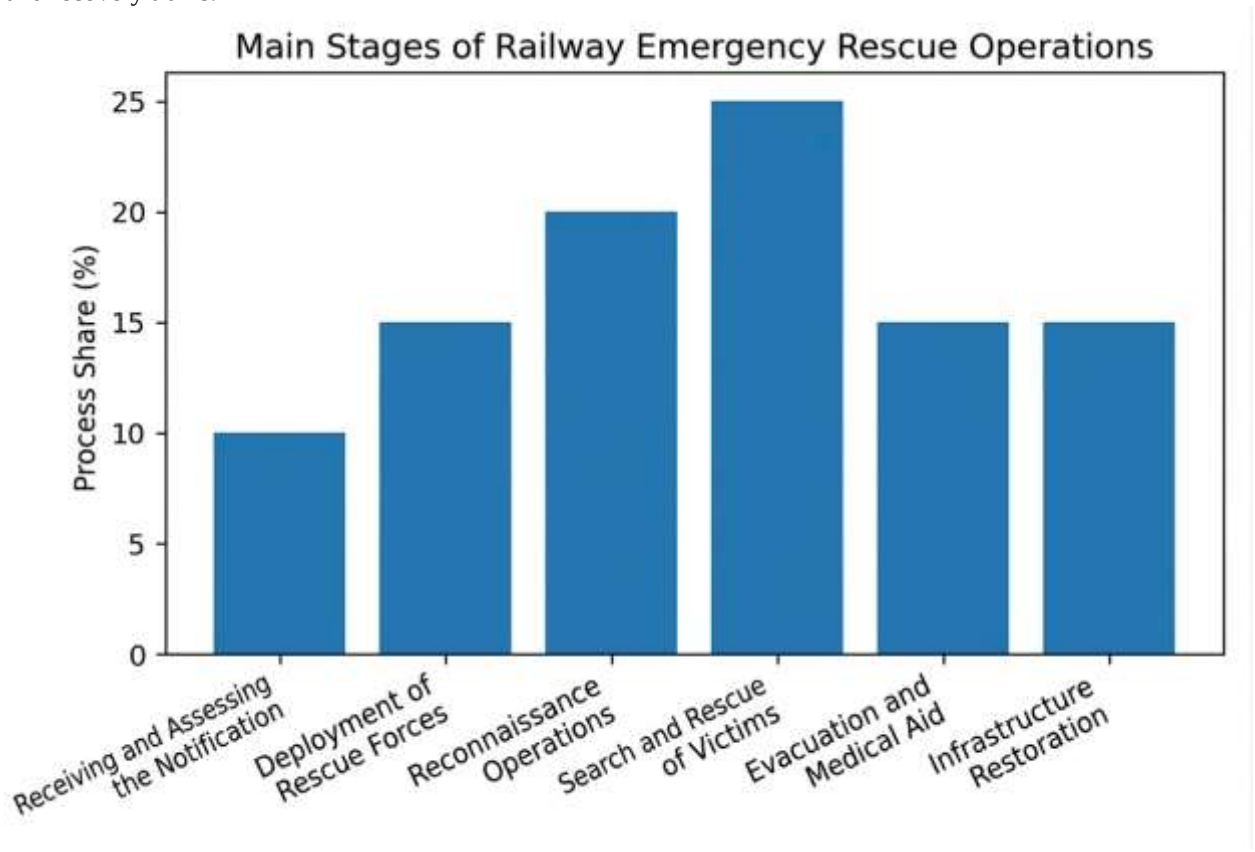


Figure 1. Main stages of emergency rescue operations in railway transport.

Thus, the organization of rescue operations in railway transport is a multi-stage and complex process that plays an important role in reducing the consequences of emergencies and ensuring the stable functioning of the transport system.

When emergencies occur in railway transport, rescue and other urgent operations are carried out in a strictly defined sequence. This process includes receiving information about the emergency, mobilizing rescue forces and resources, conducting

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reconnaissance, rescuing victims, and restoring railway traffic. The general organizational scheme of rescue operations is presented in Figure 1.



Figure 1. General scheme of rescue and emergency recovery works in railway transport.

Figure 1 illustrates the general scheme for organizing rescue and emergency recovery operations in railway transport. This scheme reflects the interaction between management authorities, rescue units, and specialized technical equipment in eliminating emergency situations. The sequential implementation of the stages presented in the scheme makes it possible to increase the effectiveness of rescue operations and prevent secondary hazards.

One of the most dangerous types of emergencies in railway transport is accidents that occur during the transportation of hazardous materials. In such cases, there is a high risk of explosions, fires, and the spread of toxic and radioactive substances, which requires special precautions when conducting rescue operations. The process of eliminating emergencies related to hazardous materials is presented in Figure 2.



Figure 2. The process of eliminating emergencies involving hazardous goods in railway transport.

Figure 2 illustrates the process of eliminating accidents that occur in railway wagons transporting hazardous materials. In such situations, the main objectives of rescue operations are to prevent explosions and the spread of toxic substances, localize fires, and evacuate the population and personnel to safe areas. At the same time, the use of personal protective equipment by rescue workers is mandatory.

The practical stage of rescue operations includes search, rescue, and evacuation activities carried out directly at the scene of the incident. At this stage, the promptness of rescue personnel, the proper use of technical equipment, and strict adherence to safety regulations are of critical importance. The process of carrying out rescue operations in railway transport is presented in Figure 3.



Figure 3. The process of conducting emergency rescue operations in railway transport.

The practical stage of rescue operations includes search, rescue, and evacuation activities carried out directly at the scene of the incident. At this stage, the promptness of rescue personnel, the proper use of technical equipment, and strict adherence to safety regulations are of critical importance. The process of carrying out rescue operations in railway transport is presented in Figure

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Table 1

Emergency Type	Number of Units Involved	Average Duration (hours)
Train derailment	3–5 units	6–12
Fire	4–6 units	4–10
Hazardous material spill	5–8 units	8–24
Explosion hazard	6–10 units	12–36

Table 1 presents the number of units involved in rescue operations and the average duration of work for different types of emergencies that may occur in railway transport. The data in the table indicate a direct relationship between the complexity level of emergencies and the duration of rescue operations.

In cases of train derailments, typically 3–5 rescue units are deployed, and the average duration of operations ranges from 6 to 12 hours. In such situations, most of the time is spent on restoring rolling stock to the tracks, separating damaged wagons, and clearing the railway line. If there are casualties, search and evacuation operations are also conducted.

In fire-related emergencies, 4–6 units are usually involved, and operations may last from 4 to 10 hours. Rapid localization of the fire significantly reduces the duration of operations. However, in cases involving flammable liquids or tank wagons, the time required may increase.

In incidents involving hazardous material spills, 5–8 specialized units are deployed, including chemical protection and decontamination teams. Operations may last from 8 to 24 hours, as they involve neutralizing toxic substances, cleaning the affected area, and carrying out sanitation measures.

The most complex situations are those associated with explosion risks. In such cases, 6–10 units are involved, and the duration of operations can reach 12 to 36 hours. This is due to the need to establish safety zones, neutralize hazardous cargo, and restore infrastructure.

The table data show that as the level of hazard increases:

the number of forces and resources involved increases;

the duration of rescue operations becomes longer;

the need for specialized protective and technical equipment grows.

This confirms the necessity of advance planning of emergency response in railway transport, optimal allocation of forces and resources, and the establishment of a rapid management system appropriate to the level of risk.

Among the most complex and dangerous types of emergencies occurring at railway transport facilities are those related to fires, explosions, radiation, and chemical contamination. These types of situations pose a significant threat to human life, the environment, and transport infrastructure. Therefore, organizing rescue operations under such conditions requires a specialized approach and the implementation of specific protective measures.

In railway transport, fires most commonly occur in passenger cars, platforms carrying flammable cargo, and tank wagons. During a fire, the main hazard factors include high temperatures, smoke, toxic gases, and the risk of explosion. The first stage of rescue operations involves the rapid evacuation of people. At the same time, measures are taken to localize the fire and prevent its spread to adjacent wagons.

In electrified sections, the power supply must first be disconnected in the event of a fire. Firefighting operations involve the use of water, foam, powder, and gas extinguishing agents. In the case of tank wagons carrying flammable liquids, continuous cooling is applied due to the high risk of explosion.

Explosion risks typically arise in tank wagons filled with explosive substances or gases. In such situations, the primary objective is to prevent an explosion and evacuate people to safe areas. Rescue personnel are equipped with protective clothing and respiratory protection equipment.

Operations in areas with explosion risk are conducted within a strictly controlled safety perimeter. If necessary, hazardous cargo is relocated to a safer area or neutralized using specialized technical means.

Radiation hazards mainly occur in accidents involving wagons transporting radioactive materials. In such cases, dosimetric monitoring is of primary importance. Before initiating rescue operations, radiation levels are measured and safety zones are established.

Under radiation hazard conditions, rescue personnel are equipped with special protective clothing, dosimeters, and filtering masks. Working time is limited, and radiation exposure levels are strictly controlled. The contaminated area is subject to decontamination procedures.

Rescue Operations under Radiation Hazard Conditions

Radiation hazards mainly occur in accidents involving wagons transporting radioactive materials. In such cases, dosimetric monitoring is of primary importance. Before initiating rescue operations, radiation levels are measured and safety zones are established.

Under radiation hazard conditions, rescue personnel are equipped with special protective clothing, dosimeters, and filtering masks. Working time is limited, and radiation exposure levels are strictly controlled. The contaminated area is subject to decontamination procedures.

Chemical hazards arise as a result of spills of toxic or highly hazardous substances. In such situations, the main objective is to contain the spread of hazardous substances and protect people. Rescue personnel use insulating protective suits and gas protection equipment.

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Spilled substances are collected using special absorbents or neutralized with appropriate chemical agents. Sanitary treatment of the affected area is then carried out.

Thus, organizing rescue operations under conditions of fire, explosion, radiation, and chemical hazards requires a high level of preparedness, modern technical equipment, and strict adherence to safety measures.

Emergencies occurring in railway transport pose serious threats to human life, the environment, and the economy. The scientifically grounded organization of rescue and other urgent operations makes it possible to reduce the consequences of emergencies and rapidly restore transport operations.

The results of the study show that the effectiveness of rescue operations directly depends on proper planning, coordination between services, the level of technical equipment, and the professional training of personnel.

Organize regular training exercises on emergency response in railway transport;

Strengthen control systems for the transportation of hazardous materials;
Equip rescue trains with modern equipment and protective gear;

Upgrade radiation and chemical monitoring systems;
Implement digital rapid-response management systems for emergency situations.

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