Ministry of Agriculture of the Russian Federation
Federal State Budgetary Educational Institution of Higher Education
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MONITORING AND FORECASTING EMERGENCY SITUATIONS

Study guide

Direction of training
20.03.01 Technosphere safety

Moscow 2023

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Monitoring and forecasting of emergency situations: a textbook for the direction of training 20.03.01 Technosphere safety / L.A. Zhuravleva // Russian State Agrarian University - Moscow Timiryazev Agricultural Academy –Moscow, 2023– 65 p.

The textbook "Fundamentals of monitoring and forecasting of emergency situations" is compiled in accordance with the work program of the discipline and is intended for students of the training direction 20.03.01 Technosphere safety. The textbook contains theoretical material on the main issues of monitoring and forecasting of emergency situations. It is aimed at the formation of students' knowledge of the regulatory and legal foundations of monitoring, forecasting and prevention of emergencies, methods of forecasting various phenomena, the ability to develop operational forecasts of natural phenomena.

ISBN 978-5-00207-320-7

Introduction

Natural and man-made disasters are terrible in their suddenness and great destructive power, in a short period of time they are able to take away many human lives, devastate the territory, destroy houses, communications, destroy property, take entire regions out of the normal process of life. To predict disasters and natural disasters and effectively eliminate their consequences, deep and extensive knowledge about their genesis, causes, nature and mechanism of their manifestation is necessary. Timely and accurate forecast is the main condition for successful and effective protection against natural emergencies, that is, it is part of the risk management process. Risk management is a systematic approach used in making policy decisions, in implementing procedures and practical measures to prevent or reduce disasters that pose a danger to the population, the economy, and harm the environment. The effectiveness of risk assessment depends on many factors. First of all, it depends on the correctness of the chosen methodology, the accuracy of its calculations, as well as on the level of technological equipment in the practical application of the techniques, meaning: the availability of a database, the duration and spatio-temporal coverage of observations of natural processes, ways of monitoring the environment. Forecasts based on the analysis of natural and man-made factors with modeling the prospects for the development of the situation can be highly effective. The textbook "Fundamentals of monitoring and forecasting of emergency situations" is intended for students in the field of training 20.03.01 Technosphere safety. The basic knowledge that a student should have after studying the discipline is designed to contribute to the development of disciplines aimed at the formation of professional knowledge and skills.

1 GENERAL CHARACTERISTICS OF EMERGENCY SITUATIONS. FORECASTING AND ASSESSMENT OF POSSIBLE CONSEQUENCES

General characteristics of emergency situations

An emergency situation (emergency) is a situation formed as a result of natural disasters, industrial accidents and other disasters, characterized by a significant violation of the normal life of the population, the functioning of economic facilities, public life and the natural environment.

The source of an emergency is a dangerous natural phenomenon, an accident, a widespread infectious disease of people, farm animals and plants, as well as the use of modern means of destruction, as a result of which an emergency has occurred or may occur.

An accident is a dangerous man–made accident that creates a threat to human life and health at an object, a certain territory or water area and leads to the destruction of buildings, structures, equipment and vehicles, disruption of the transport or production process, as well as damage to the environment.

A disaster is a major accident, usually with numerous human casualties, significant material damage and other serious consequences.

The territory affected by dangerous and harmful emergency factors, with the population, animals, buildings and structures, engineering networks and communications located on it, is called a lesion center.

A simple lesion is called a lesion that has arisen under the influence of one damaging factor, for example, destruction from an explosion. Complex lesions occur as a result of the action of several damaging factors of emergency. For example, an explosion at a chemical plant entails destruction, fires, chemical contamination of the surrounding area.

Stages of emergency development:

- the stage of origin - the conditions and prerequisites for a future emergency are formed (unfavorable natural processes are activated, design and production defects of structures and numerous technical malfunctions accumulate, equipment, personnel malfunctions occur, etc.);

- the stage of initiation - an emergency is launched, with the most significant influence of the human factor (statistics show that over 60% of accidents occur due to erroneous actions of personnel);

- culmination stage - characterized by the release of energy or substances that have an adverse effect on the population and the environment;

- the stage of attenuation of an emergency - covers the period from the overlap (limitation) of the source of danger - localization of an emergency - to the complete elimination of its direct and indirect consequences, the duration of this stage can be years, or even decades.

Classification of emergency situations

Each emergency has its own physical essence, its own inherent causes, driving forces, the nature of development, its own characteristics of the impact on a person and his environment.

Based on this, all emergencies can be classified (systematized) according to different characteristics.

1. By the nature of origin:

• natural disasters are dangerous natural phenomena or processes that have an extraordinary nature and lead to disruption of the daily way of life of more or less significant groups of the population, human casualties, destruction of material assets (earthquakes, floods, tsunamis, volcanic eruptions, landslides, mudflows, hurricanes, snow drifts, droughts, prolonged torrential rains, severe persistent frosts, massive spread of agricultural and forestry pests);

• man-made disasters - sudden failure of machines, mechanisms and aggregates during their operation, accompanied by serious disruption of the production process, explosions, formation of fires, radioactive, chemical or biological contamination of the area, group damage to people (accidents at industrial facilities, construction, railway, air, pipeline transport, etc.);

• anthropogenic catastrophes are qualitative changes in the biosphere caused by the action of anthropogenic factors generated by human activity and having a harmful effect on people, the animal and plant world, the environment as a whole;

• socio-political conflicts are an extremely acute form of resolving contradictions between states with the use of modern means of destruction, as well as interethnic crises accompanied by violence.

2. According to the speed of danger propagation:

• sudden (earthquakes, explosions, transport accidents, etc.);

• rapid (fires, hydrodynamic accidents with the formation of a breakthrough wave, accidents with the release of SDS, etc.);

• moderate (flood floods, volcanic eruptions, accidents with the release of radioactive substances, etc.);

• smooth - with a slowly spreading danger (droughts, epidemics, soil pollution, etc.).

3. According to the scale of the defeat and the resources involved to eliminate the consequences:

• local (object) - the consequences are limited to the limits of the object of the economy and can be eliminated at the expense of its forces and resources;

• local have the scale of distribution within a locality, including a large city, an administrative district and can be eliminated at the expense of the forces and resources of the region;

• regional are limited to the limits of several regions or an economic area;

• national have consequences that cover several economic areas, but do not go beyond the borders of the country, the elimination of such emergencies is carried out by the forces and resources of the state, often with the involvement of foreign aid;

• global ones go beyond the borders of the country and affect other states, the consequences are eliminated both by the forces of each State on its territory and by the forces of the international community.

Forecasting and assessment of possible consequences of an emergency

Emergency forecasting is the process of indicative identification and assessment of the situation that develops as a result of natural disasters, accidents and catastrophes. The difficulty lies in the fact that it is required to assess the area, nature and extent of the emergency in the conditions of incomplete and unreliable information, and on their basis to roughly determine the nature and scope of work to eliminate the consequences of the emergency.

The task of forecasting in the field of life safety also includes an approximate determination of the time of occurrence of an emergency (short-term forecast), on the basis of which operational decisions are made to ensure the safety of the population in all areas of its activities.

For example, hurricanes, typhoons, volcanic eruptions are predicted using meteorological satellites of the Earth. Earthquake prediction is possible through systematic analyses of the chemical composition of water in seismic areas, changes in the elastic, electrical and magnetic characteristics of the soil, observation of changes in the water level in wells, the behavior of animals, reptiles, fish and birds.

Forecasting of the situation associated with the occurrence of an emergency is carried out by mathematical methods. The initial data for predicting the situation are: locations (coordinates) of potentially dangerous objects and reserves of substances or energy; the number and density of the population, the nature of buildings, the number and type of protective structures, their capacity, etc. When forecasting, the nature of the terrain, meteorological conditions are taken into account.

The data of predicting the situation in the lesions are summarized and analyzed. Based on this analysis, conclusions are drawn for decision-making related to the organization and provision of security in emergencies.

Advance preparation for emergencies

The measures necessary to prevent damage from an emergency can be grouped as follows:

1) background (ongoing) activities based on a long-term forecast:

• performing construction and installation works taking into account safety requirements, creating a reliable public alert system about the danger;

• accumulation of the fund of protective structures and provision of the population with PPE;

• organization of radiation, chemical and bacteriological surveillance, mandatory universal training of the population in the rules of behavior and actions in emergencies;

• carrying out routine, sanitary-hygienic and anti-epidemic measures;

• refusal to build nuclear power plants, chemical and other potentially hazardous facilities in environmentally vulnerable areas;

• repurposing of objects - sources of increased danger to human health and life;

• development, material, financial support and practical elaboration of emergency response plans, etc.2). Защитные мероприятия, которые необходимы, когда предсказан момент ЧС:

• deployment of the surveillance and reconnaissance system necessary to clarify the forecast; alerting the emergency warning system to the public;

• putting into effect special rules for the functioning of the economy and public life up to the state of emergency;

• neutralization of sources of increased danger in emergencies (nuclear power plants, toxic and explosive industries, etc.), termination of operations with them, additional strengthening or dismantling;

• alerting emergency services;

• partial evacuation of the population.

The listed measures have different implementation costs and different effectiveness. The choice of a specific set of these measures is determined based on an assessment of the possible consequences of an emergency and damage.

Protection of the population in emergency situations

In modern conditions, the protection of the population is carried out by carrying out a set of measures, including three methods of protection:

- shelter of people in protective structures;
- dispersal and evacuation;
- provision of personal protective equipment.

Civil defense protective structures are divided into shelters and radiation shelters according to their purpose and protective properties.

Shelters are structures designed to protect people from weapons of mass destruction.

They must:

- to protect people hiding in them from damaging factors, it is built on areas that are not subject to flooding, to have entrances and exits with the same degree of protection as the main premises, and in case of their blockage - emergency exits;
- have free approaches where there should be no combustible or highly smoky materials.

The filter ventilation equipment of the shelter must purify the air from all harmful impurities and ensure the supply of clean air within the established norms. In normal times, shelters can be used for cultural and household purposes (red corners, small workshops, training centers, classes for various circles), pedestrian and transport tunnels, garages for cars, warehouses for storing fireproof materials, etc. The dual use of shelters must be provided at the stage of their design. The use of shelters for industrial and household needs should not violate their protective properties.

Anti-radiation shelters are protective structures that protect people hiding in them from contamination with radioactive substances and from radiation exposure in areas of radioactive contamination of the area.

Dispersal is the organized removal (withdrawal) and placement in the suburban area of the personnel of enterprises and organizations that continue to work in cities, this category of the population goes to the city to work and returns to the suburban area after work.

A suburban area is an area outside the zones of possible destruction. The boundary of the zones of possible destruction is determined depending on the value of the city and its population. Evacuation is the organized removal (withdrawal) of personnel of organizations and enterprises that stop or transfer their activities to a suburban area, as well as the disabled and unemployed population.

In the shortest possible time, dispersal and evacuation can be carried out in a combined way, which consists in combining the mass withdrawal of the population on foot with the removal of certain categories of the population by all types of available transport.

For the resettlement of dispersed and evacuated people, it is planned to use the houses of local residents, and for the accommodation of institutions - tourist and sports bases, schools, clubs, etc. On a city scale, dispersal and evacuation is planned by the headquarters of the civil defense of the city. The initial data for planning are:

- total population;
- the number of enterprises, institutions, educational institutions, etc.;
- the number of workers and employees subject to dispersal, and their family members;
- the number of the population to be evacuated;
- the number of rural settlements and premises in them suitable for housing people and organizations in them;
- availability of all types of message paths and their throughput.

Evacuation commissions are set up in organizations to prepare and carry out dispersal and evacuation measures, and evacuation commissions are set up in rural areas. The population is notified about the beginning of the evacuation through enterprises, institutions, educational institutions and police authorities. Having received the notification of the dispersal and evacuation, citizens must arrive at the combined evacuation point (SEP) exactly at the specified time. Everyone should take with them a passport, a military ID card, educational documents, a work book or a pension certificate, birth certificates of children, a stock of food (for 2-3 days), personal belongings, taking into account a long stay in a suburban area. Preschool children need to put notes in their pockets or sew them to their clothes indicating the surname, first name, patronymic and place of residence or work of their parents.

Before leaving the apartment, it is necessary to turn off the electricity and gas, and then close the apartment.

At the BOT, evacuees are registered, grouped by train cars or by cars (ships) and at the appointed time are taken to the boarding points for transport. Citizens evacuated on foot are registered at the EPA, after which they are reduced to 500-1000 people on foot, formed by enterprises.

The head of the walking column is given a scheme of the march of the column. The speed of movement is calculated no more than 3-4 km / h, every 1-1.5 hours of movement, a small halt of 15 minutes is provided, and at the beginning of the second half of the daily transition - a large halt for 1-2 hours.

The daily transition ends with the arrival at the intermediate evacuation point.

According to their purpose, personal protective equipment is divided into respiratory protection and skin protection. According to the principle of protection, they are divided into insulating and filtering. Filtering gas masks, insulating gas masks, respirators, protective baby chambers for infants can be used to protect the respiratory organs. In addition, there are means of medical prevention to protect against harmful factors of emergencies.

Moral and psychological preparation for actions in an emergency

The impact of an emergency on the human psyche has 2 levels:

- individual reaction when a person develops a state of fear, anxiety. If a person is not able to cope with these manifestations on their own, then it is necessary to use special treatment, but the use of antidepressants is irrational until the sources of danger are eliminated;
- group reaction when panic is formed. Panic is the reaction of people to an imaginary or real danger, while losing the ability to rationally assess the situation, take protective measures.

The causes of panic are:

-lack of information about possible rescue methods;

-fear that the exits are either already blocked or will be (bottleneck syndrome);

- the presence of panic initiators;
- spreading rumors;
- distrust of government and law enforcement agencies.

Measures to prevent panic:

- bring information about the danger only to those who are directly threatened by it;
- break the crowd into smaller but manageable groups or prevent the formation of a crowd;

- isolation of panic initiators;
- competent actions, clear and understandable to people, governing bodies and law enforcement agencies must demonstrate their competence, which will increase confidence in them.

When panic occurs, it is necessary to use strong expressive means to try to switch people's attention and cause a state other than fear (surprise). In order to increase the stability of the human psyche to emergencies, it is necessary to teach the population the rules of behavior in emergencies, to conduct training in filling protective structures. The governing bodies increase their preparedness as a result of the exercises.

Ensuring the sustainable operation of an economic facility in an emergency

The stability of the operation of an economic object (OE) in an emergency is understood as the ability to withstand the destructive effects of the damaging factors of an emergency, to produce products in the planned volume and nomenclature, to ensure the safety of personnel, as well as the adaptability to restore their production in case of damage.

The stable operation of the facility in an emergency can be achieved by carrying out a complex of organizational, engineering, technical and other measures. These measures are primarily aimed at protecting workers and employees from the damaging factors of an emergency; they are closely related to measures for the preparation and conduct of rescue and other urgent work, since without human resources and successful liquidation of the consequences of an emergency, it is almost impossible to carry out measures to ensure the sustainable operation of the OE in this case.

The process of developing measures to ensure the sustainable operation of the enterprise consists of an analysis of the vulnerability of the facility and its elements, an assessment of the possibility of its functioning in an emergency and the development on this basis of measures to improve the reliability of the facility. The conditions for the placement of internal technological equipment are considered and the types of destruction and damage that may occur in an emergency are determined. It is especially important to determine the protection of valuable and unique equipment and the possibility of continuing production in case of failure of control and measuring equipment. When examining the utility and energy systems of an object, the parameters of the damaging factors under which the networks receive certain destructions are determined.

The system of logistics and industrial relations is analyzed. The volume of stocks and possible terms of continuation of work without deliveries are established; compliance of their quantity and nomenclature with the requirements for production in an emergency is determined. The stability of warehouses of raw materials, components, finished products and other materials, as well as storage of combustible materials, is evaluated.

Under normal production conditions, measures are carried out at the facility to ensure trouble-free and safe operation. However, in an emergency, these measures may not be enough; therefore, additional measures are needed to limit the effect of secondary factors in an emergency. Such measures include:

-reduction of stocks of explosive, explosive and fire-hazardous substances to a minimum and their storage in protected storage facilities;

- the use of devices that exclude the spillage of toxic, flammable and aggressive liquids;
- placement of warehouses of wood, pesticides, LVZH, taking into account the direction of the prevailing winds;
- digging into the ground of technological communications, power supply lines, etc.

Questions for self-control

1) What does the term "emergency" mean?
2) What does the term "accident" mean?
3) What does the term "catastrophe" mean?
4) List the main stages of an emergency.
5) Classification of emergencies by the nature of origin.
6) Classification of emergencies according to the speed of propagation of danger.
7) Classification of emergencies by the scale of defeat.
8) What does emergency forecasting include?
9) List the main measures necessary to prevent damage from an emergency
10) What does the protection of the population in an emergency include
11) General requirements for protective structures.

2 NATURAL EMERGENCIES

The population and the territory of the Earth with numerous facilities of the economy are subject to the negative effects of more than 50 dangerous natural and man-made processes.

Depending on the specific climatic conditions and heliophysical factors of each year (or a number of years), the risk of some of them increases and the risk of others decreases.

In recent years, there has been a tendency to reduce the number of natural disasters and emergencies of a natural nature. This is caused by both natural and socio-economic reasons, which consist in the progressive development of the economy in the last 3 years and an increase in spending on current and capital protective measures.

From the point of view of the possibility of carrying out preventive measures, dangerous natural processes, as a source of emergency situations, can be predicted with very little advance time.

In recent years, due to the general trends of climate change, warming has been observed almost throughout the territory and the risk of droughts and fires in forests has increased.

An increase in the frequency of unfavorable short-term phenomena is predicted (out-of-hours periods of abnormally warm weather and frosts, strong winds and snowfalls, etc.). A decrease in the frequency of particularly dangerous heavy and prolonged rains, and other particularly dangerous phenomena associated with humidification is expected.

The decrease in the period of weather changes noted in recent years - 3-4 days versus the usual 6-7 days - will cause certain difficulties in predicting natural hydrometeorological phenomena, which will affect the degree of prompt notification of them and, to a greater extent, the possibility of predicting their consequences.

As before, the issue of changes in the local climate and local weather conditions remains particularly relevant in relation to urban settlements, especially large urban agglomerations, where factors independent of natural weather conditions transform meteorological processes to completely unpredictable manifestations.

Floods, flood situation

The regions to which floods cause the greatest damage are areas with wide estuaries. A scientifically based forecast of the hydrological regime of rivers is carried out by a hydrometeorologist at the end of winter based on an assessment of the formed snow reserves.

We can expect a reduction in the risk of spring floods with a lower water content of rivers.

Flooding from congestion-type floods, which do not depend much on the water level of the year, should be expected in April-May. The unsatisfactory technical condition of retaining hydraulic structures of both large and small reservoirs is alarming.

The situation may be complicated by the circumstance when hydraulic structures of small and medium-sized reservoirs may turn out to be unattended, which creates an increased threat of their breakthrough in case of intense snow melting in spring or prolonged rains in summer and autumn, Fig. 1.

Winds, rains, hail

The forecast of strong winds and the intensity of rains has a short-term lead time (from several days to several hours). Strong winds with a speed of over 20 m/s and heavy rainfall can be observed in almost all regions.

If the trend continues, the greatest number of strong winds should be expected in the period from May to August.

Tornadoes are most likely to occur in the central regions, and they are most often observed in June-July. In recent years, there has been a decrease in the number of tornadoes, which is presumably associated with an increase in the frequency of the western form of atmospheric circulation.

Figure 1 – Flooding as a result of heavy rains

Coastal erosion

Due to the curtailment of coastal protection works in recent years and the deterioration of existing coastal protection structures, the threat of large-scale collapses of economic and life support facilities located in the immediate vicinity of collapsing river banks and reservoirs has seriously increased, Fig.2. Of particular concern is the possibility of destruction of sewer collectors with the subsequent discharge of large volumes of polluted water into river systems.

Karst processes

Karst processes. The increased risk of emergency situations caused by the activation of karst processes is characteristic of urbanized areas experiencing man-made flooding.

The danger of karst processes is high in large cities, and their activation is caused, as a rule, by non-compliance with the norms of construction and operation of urban underground utilities, as well as irrational underground mining.

Wildfires

Methods of long-term forecasting have not yet received practical confirmation. As world experience shows, real forecasting of the occurrence and development of a fire situation is possible only with a lead time of no more than 5 days, but the reliability of even such short-term forecasts does not exceed 50%.

Figure 2 Coastal erosion

Any reliable assessment of the fire season can be given no earlier than March on the basis of hydromet data on the main components of the water balance at the beginning of snowmelt, the timing of snowmelt and the estimated meteorological forecast of temperature and precipitation regimes.

However, there are traditionally dangerous regions on the territory of the regions, where the fire season is tense every year. As usual, a difficult fire situation is expected mainly in the southern regions.

The main spring fires will take place as usual in April-May. From the point of view of the probability of emergency situations, the greatest danger may be summer-autumn fires. The main cause of fires remains mainly anthropogenic factor - about 90%, in the north-western regions of the country - anthropogenic factor - 60% and lightning discharges - up to 40%.

The probability of peat fires is quite high, which is also facilitated by the curtailment of preventive measures at peat mining facilities.

Questions for self-control

1) List the main natural emergencies
2) Flood predictability. Flood situation.

3) The predictability of winds and rains.
4) Coastal erosion. Karst processes.
5) The predictability of wildfires.

3 TECHNOGENIC EMERGENCIES

In the field of technogenic danger, it is expected:

• increasing potential hazards and increasing their risk of emergencies in the technogenic sphere;

• expansion of industrial production;

• strengthening measures to counter man-made disasters and reduce the risks of man-made emergencies.

The main directions of the formation of technogenic danger in the country will be determined by such types of emergencies as fires and explosions in residential buildings and hazardous production facilities, emissions of chemically hazardous substances, accidents on main pipelines and utility and energy networks, major car accidents. The probability of breakthroughs of the pressure front of reservoirs remains.

Analysis of statistical data on emergencies that occurred in the period from 1996 to the present, the degree of depreciation of fixed assets, the general level of industrial safety of production, the expected temperature regime for the forecast period and a number of other factors shows that the expected excess of the average annual number of man-made emergencies by 10% or more.

This is mainly caused by a significant increase in loads on power supply systems in the cold season, severe operating conditions of technological equipment with large temperature and humidity fluctuations, soil deformations during freezing and thawing, etc.

We should expect a possible increase in the number of man-made emergencies at energy facilities and main heating networks due to the insufficient volume of planned repair and preparatory work.

The main causes of man-made emergencies, as before, will be untimely and poor-quality repair of equipment, slow resolution of issues related to equipping hazardous facilities with means of explosion prevention, localization of emissions of explosive and toxic products into the atmosphere, as well as insufficient supervision of the condition of equipment and pipelines, fire safety in residential and socio-cultural buildings.

The probability of large fires at oil depots and oil refining plants will remain significant.

A number of chemical facilities are slowly being equipped with hazardous environmental production systems for emergency purposes. As a result, it is possible to repeat major accidents associated with the release of hazardous substances into the atmosphere and the defeat of people.

Due to the lack of an effective system of technical supervision over the condition of hydraulic structures (GTS) for industrial and water management purposes, slow resolution of issues related to improving their safety, failure to take timely measures to repair and maintain structures and equipment, the possibility of breakthroughs of the pressure front of reservoirs, pollution of water basins with harmful products remains.

Railway transport

The wear and tear of the rolling stock and the upper structures of the track will continue to be the determining factor affecting the safety of movement on railway transport.

It is also predicted to reduce the accident rate during the transportation of dangerous goods in connection with the work on improving the rules of their transportation. A positive factor affecting the reduction of the risk of an emergency in railway transport is also the introduction of automated systems for tracking dangerous goods in motion on a number of roads.

Road transport

Unfortunately, the number of car accidents is not decreasing, Figure 3. The number of deaths per 100 victims (the severity of the consequences of an accident) continues to remain at an unacceptably high level – 14 people. While in a number of Western countries, it does not exceed 5 deaths per 100 victims.

To a large extent, this state of affairs is due to the sharply increased number of motor vehicles owned by individuals and the weakening of the personal discipline of road users.

Some optimism is caused by the activation of the activities of the concerned federal executive authorities to reduce accidents on highways.

Figure 3 Car accident

Pipelines

Currently, the number of accidents on main and in-field pipelines has continued to decrease compared to 2001.

This became possible as a result of the allocation of the necessary financial resources for repairs of the linear part and technical measures to diagnose the condition of pipelines.

However, just as before, accidents occurred due to external mechanical influences, criminal actions for the purpose of theft of transported products, as well as defects during construction and installation works and deviations from design solutions, corrosion wear of pipes, shut-off and control valves. As before, the main pipelines remain vulnerable to terrorist attacks, the likelihood of which remains.

Electric power industry

Due to the general deterioration and development of the design resource of a significant part of the technological equipment of thermal power plants and boiler houses, failure to fully implement measures for planned preventive maintenance of equipment due to underfunding, as well as due to a general decrease in the level of technological discipline, there is an increase in the number of accidents, including fires. Based on the above, it can be concluded that the listed reasons will be the main ones in the event of technological accidents and fires at thermal power plants and boiler houses, and the scale of possible consequences will not exceed the level of last year.

Questions for self-control

1) List the main technogenic emergencies
2) The main causes of man-made accidents on railway transport
3) The main causes of man-made accidents in road transport
4) The main causes of man-made accidents in pipeline transport
5) The main causes of man-made accidents in the electric power industry

4 ENSURING SAFETY IN THE AFTERMATH OF AN EMERGENCY. ADVANCE PREPARATION

Emergency response

All work to eliminate the consequences of emergency situations is carried out in stages in a certain sequence in the shortest possible time. At the first stage, three groups of measures are carried out simultaneously:

• emergency protection of the population: notification of danger, use of protective equipment, compliance with the behavior regime, evacuation from dangerous zones, provision of medical and other types of assistance to victims;

• prevention of the development or reduction of the consequences of an emergency, localization of accidents, suspension or modification of the technological process of production, disconnection of communications;

• preparation for rescue and other urgent work: alerting management bodies, forces and means, conducting reconnaissance of the lesion and assessing the current situation.

At the second stage, rescue and other urgent work is carried out.

At the same time, the activities initiated at the first stage are continuing.

Rescue operations include searching for victims, removing them from rubble, burning buildings, evacuating people from dangerous areas, providing necessary assistance.

Urgent works include: localization and extinguishing of fires, dismantling of rubble, strengthening of structures threatening collapse, restoration of utility and energy networks, communication lines and roads in the interests of providing rescue operations, sanitary treatment of people, etc.

Rescue and other urgent work is carried out continuously with the necessary change of rescuers and liquidators and compliance with safety and precautionary measures. At the same time, special attention should be paid to the accommodation of the affected population, providing them with food, water, and basic necessities.

At the third stage, tasks are being solved to ensure the vital activity of the population in areas affected by emergencies, and work is beginning to restore the functioning of economic facilities.

Ensuring security. Advance preparation

Forest fires

Forest fires are uncontrolled burning of vegetation that spreads through the forest. Gorenje.

According to statistics, the main causes of forest fires in Russia are, violation of fire safety rules by the local population - 70% and lightning - 12.4% (in Canada, for example, every fourth forest fire is caused by lightning).

Depending on the type of combustible materials , forest fires are divided into the following groups:

1. grass–roots forest fires that develop as a result of the combustion of coniferous undergrowth and ground cover, the speed of propagation is 0.1-0.2 km / h, with strong winds - up to 1 km / h, the height of the flame reaches 1.5-2 m; grass-roots fires, in turn, are divided into runaway and stable fires;

• runaway grass-roots fires are characterized by a rapidly moving edge of flame and light gray smoke, uneven progress;

• stable grass-roots fires completely burn the ground cover, the height of the flame is higher than that of runaway ones, but the speed is less;

2. upper forest fires, in which not only the ground cover burns, but also the canopy of the stand, develop from lower fires, the height of the flame reaches 100 m, large fires are accompanied by the transfer of flames over considerable distances with the formation of vortices;

• for runaway top fires, the separation of burning along the canopy of the stand from the edge of the bottom fire is characteristic, the fire spreads in leaps at a speed of up to 25 km / h in strong winds, the smoke is dark in color gorenje;

3. underground peat fires most often occur at the end of summer as a continuation of ground fires, while deepening occurs at the trunk of the tree; the rate of spread is from several centimeters to several meters per day;

4. steppe (field) fires occur in open steppe terrain with dry vegetation.

The damaging factors of forest fires are high temperature, which causes the ignition of objects capable of burning, and the defeat of people; smoke in large areas, which irritates people, makes it difficult to fight a fire and limits visibility; negative psychological effect on people. Peat fires are also characterized by the formation of voids in burnt peat, where people and equipment can fall.

Activities carried out in advance to prevent forest and peat fires:

1. organization of monitoring of forests;
2. assessment of the amount of combustible substances in the territory (fallen leaves, dry trees);
3. development and creation of fire warning systems;
4. identification of water sources that can be used to extinguish fires;
5. identification of natural barriers to the spread of fire (ravines, clearing, highways, etc.);
6. creation of new glades to limit the spread of fire;
7. logging – forest care;
8. organization of hydrometeorological observation;
9. creation and training of a fire-fighting formation;
10. accumulation of fire extinguishing and technical means of extinguishing.

When a forest fire is threatened, it is necessary to carry out:

1. increased control over the state of the forest;
2. bringing formations and technical means of fire extinguishing into readiness;
3. ban on the access of vacationers to forests, etc.

Activities carried out in case of forest fires: first of all, fire reconnaissance is organized, which establishes the places, sizes and boundaries of fires, the direction, the degree of their danger and the possibility of spreading, as well as the presence and condition of water sources and the route to the place of fire.

Fighting forest fires can be carried out in one of three ways: active, passive and a combination of active and passive methods.

1. an active method of fire fighting is used if there are sufficient forces and means to fight fires. With an active method to localize a forest fire, it is necessary first of all to stop the fire front; then, by focusing efforts on the flanks, to prevent the

expansion of the fire front; after that, by focusing efforts on the rear edge of the fire, strive to eliminate gorenje.

2. the passive method consists in retreating to a pre-prepared or natural boundary and fighting a fire with a lack of strength.

3. a combination of active and passive methods is used to extinguish several or large fires.

Extinguishing forest fires includes the following steps:

• stopping the fire - eliminating the edge of the fire, i.e. stopping the spread of fire;

• localization - suppression of foci, as a rule, of flameless gorenje (smoldering) in the area of the extinguished edge;

•extinguishing - suppression of fire sources in the gorenje at a distance that excludes the possibility of repeated fires;

•guarding - protection of places where fires have been extinguished to prevent the occurrence of repeated fires.

Floods

Floods are significant flooding of an area that occurs as a result of rising water levels in a river, lake, sea or artificial reservoir.

The causes of flooding are:

1. heavy rains;
2. abundant and rapid melting of snow or cluttering of riverbeds during ice drift;
3. earthquakes;
4. destruction of hydraulic structures;
5. wind surges of water from the sea to the estuaries of rivers.

Advance preparation in flood areas:

1. reasonable use of those territories that are periodically flooded;
2. deepening, correction of riverbed;
3. condition control, timely repair and protection of hydraulic structures;
4. construction of dams, dams and other hydraulic structures regulating the flow of rivers;

5 determination of elevated areas of territories to which the population, farm animals, material values, etc. can be evacuated.

6. creation of notification systems;
7. accumulation of a reserve of life-saving means (for example, swimming).

Measures in case of a flood threat:

1. start of evacuation;
2. strengthening of dams and dams;
3. accumulation of sandbags;
4. if necessary, emergency shutdown of hazardous facilities, transfer of warehouses of pesticides and fertilizers to non-flooded areas;
5. notifying the population about the danger of flooding and bringing rescue equipment into full readiness.

Carrying out rescue operations in the flood area: places where people are left are installed on high-speed boats or small aircraft. Rescue vehicles are poisoned to these territories, which are engaged in their evacuation. Life-saving equipment must be provided with ladders, bags, dry clothes, medical supplies, food, etc.

Earthquakes

An earthquake is a powerful manifestation of the internal forces of the Earth, causing underground shocks and vibrations of the Earth's surface and releasing a huge amount of energy. The released energy spreads in the form of elastic seismic waves, causing disturbances of the earth's crust and destruction on its surface.

According to the causes of the earthquake , they are divided into the following types:

1. tectonic - arising from the movement of masses in the earth's crust under the influence of mining-forming processes;
2. volcanic - occurring due to volcanic eruptions;
3. landslide - occurring during the collapse of karst voids formed during the leaching of rocks by water;
4. anthropogenic - resulting from the imbalance in the earth's crust during the extraction of minerals (oil, gas, artesian water, etc.).

The following events can be the consequences of earthquakes, Fig. 4.

- formation of a tsunami;
- terrain changes, collapses;
- fires;
- toxic gases released during volcanic eruptions, lava, ash, etc.

Figure 4 - Earthquakes

Activities carried out in advance in earthquake areas:

- training of the population in earthquake behavior;
- planning of settlements and earthquake resistance of buildings to minimize the risk of blockages;
- preparation of tent facilities for their deployment in case of destruction of residential buildings;
- creation of food stocks and their dispersal;
- preparation of civil defense forces for actions in earthquake conditions;
- preparation of technical means to be used in the dismantling of rubble.

Important problems that arise during earthquakes are the organization of food and trade, the supply of medicines and basic necessities.

Major industrial accidents

A major industrial accident should be understood as significant damage accompanied by a violation of the production process of a workshop or a number of workshops at a large production facility.

The causes of major industrial accidents are:

1. disadvantages of designing enterprises, their structures;
2. lack of constant monitoring of the condition of industrial buildings and installations;
3. violation of safety requirements in production processes;
4. occurrence of accidents at neighboring enterprises or on energy and gas networks;
5. natural disasters causing accidents;
6. phenomena not known to science.

Emergency commissions should be created at enterprises, which operate in three different modes:

1. during the normal operation of the enterprise, measures are being developed and implemented to increase the stability of the facility in an emergency, emergency action plans are being developed, which should contain ready-made scenarios for actions in the event of a threat and in the event of a possible emergency, create formations based on structural units enterprises that additionally prepare for actions in the event of a threat of various emergencies;
2. in case of a threat of an accident, use an emergency action plan, prepare formations, protective equipment;
3. upon the occurrence of an accident, perform actions related to its elimination, the nature of the accident and the intensity of the damaging factors.

Questions for self-control

1) The sequence of work to eliminate the consequences of an emergency.

2) What does rescue and emergency work include?

3) Types and causes of forest fires. Methods of fighting forest fires.

4) Measures carried out in advance to prevent forest and peat fires.

5) Types, causes of floods. Measures carried out in advance to prevent flooding.

6) Types, causes of earthquakes. Activities carried out in advance to prevent earthquakes.

7). Types and causes of industrial accidents. Measures carried out in advance to prevent industrial accidents.

5 FORECASTING AND MONITORING OF EMERGENCIES

Emergency forecasting

Emergency forecasting is the process of obtaining information about the state of potentially dangerous objects or sources in a certain territory, the development of natural phenomena, environmental and biological–social disasters leading to emergencies, and the assessment of possible consequences in the event of an emergency of various nature.

Forecasting of emergency situations is carried out in advance, before their occurrence. Depending on the lead time, forecasting is divided into long-term, medium-term, short-term and direct. These deadlines for natural emergencies are shown in table 1

Types and timing of the forecast	Types of natural emergencies					
	Floods	Hurricanes, storms	Tornadoes	Landscape fires	Congestion	Earthquakes
Long-term (years)	–	–	–	–	–	+
Medium-term (months, weeks)	+	–	–	+	–	+
Short-term (days, hours)	+	+	–	+	+	+
Direct	+	+	+	+	+	+

The timing of forecasting other types of emergencies is more uncertain, since the events of their occurrence are essentially random.

The purpose of emergency forecasting is to ensure timely and effective adoption of measures of early and immediate protection.

Forecasting of man-made emergencies includes identification and certification of potentially dangerous objects, assessment of possible consequences of accidents and catastrophes at potentially dangerous objects, warning of management bodies about possible emergencies.

The solution of the problems of forecasting man-made emergencies in the Russian Federation is headed by the State Committee for Technical Control. The direct executors of predicting emergency situations are departmental control bodies. In the Ministry of Emergency Situations, for this purpose, the Department of Prevention and Liquidation of Emergency Situations is creating a system for monitoring the precursors of disasters, as well as diagnostic complexes for assessing the stability of buildings, structures, and potentially dangerous objects. The organs of such a system should function in all district centers and subjects.

Forecasting of natural emergencies is the most difficult problem due to their large scale and significant uncertainty in the occurrence and development of processes. Forecasting of natural emergencies is carried out on a national scale, and in some cases in cooperation with international organizations. The management of the entire system of observations, forecasting of meteorological and hydrological emergencies, as well as mass forest fires in the country is entrusted to the State Committee of the Russian Federation for Hydrometeorology and Environmental Control (Goskomgidromet RF). A Unified System of Seismic Observations (ESSN), including regional centers, has been deployed in the country to forecast earthquakes. Regional centers have networks of seismic stations and computing centers.

The forecast of the occurrence and development of natural emergencies is carried out in the Hydrometeorological Center of the country and its regional centers and is brought to the territorial and departmental OU GOChS by the warning system at various times. The most commonly used form of presentation is in the form of maps of an advance forecast for a certain period (year, season) or urgent information by means of communication.

Forecasting of emergency situations for wartime is carried out on the basis of an assessment of the military-political situation in the country and regions, conducted periodically at the General Staff and headquarters of military districts.

On the basis of this information, the departments of emergency prevention and response, civil defense, as well as regional centers forecast the most dangerous emergencies in this armed conflict or war. According to existing methods, the scale of lesions, possible population losses and material damage are estimated. Forecasting data are used to carry out advance protection measures to ensure the stability of objects of territories, troops of the gas and smoke protection service, as well as to prepare the population, troops and formations for actions with the outbreak of armed conflict, war.

The basis for forecasting biological and social emergencies is a retrospective epidemiological analysis, i.e. the analysis of infectious diseases at the current time, taking into account information for a certain past period. The forecast is carried out by the Main Epidemiological Department of the Ministry of Health of the Russian Federation and regional medical services. The forecasting process includes epidemiological analysis and timely notification of local authorities, healthcare and medical services of the territorial smoke protection systems of the possibility of biological and social emergencies.

The forecast of the occurrence of environmental emergencies in a certain area or at an object is carried out on the basis of continuous monitoring and control of the characteristics of the environmental situation and compliance with its safety criteria. The organization of the forecast of environmental emergencies is carried out by the State Committee for Environmental Protection and its regional and local environmental services.

In recent years, the Ministry of Emergency Situations of Russia, taking into account the importance of forecasting to reduce the risks of disasters, has been creating a nationwide system for monitoring natural and man-made emergencies. This system includes departmental and regional subsystems for monitoring emergencies.

Monitoring

Monitoring is understood as a system of observations and analysis of changes in the state of the environment caused by anthropogenic and natural causes, which makes it possible to predict the development of these changes, including those leading to emergency situations. The term "monitoring" (from Lat. monitor) means "lookout" and translates as "observing" or "warning". Monitoring includes ground, air and space surveillance means. Monitoring can be organized at the global, state, regional, territorial and local levels. The creation of a monitoring system of the Ministry of Emergency Situations was one of the main tasks of the Federal Target Programs of the Russian Federation assigned to the Ministry of Emergency Situations. Taking into account the importance of this task, in 1997, by the decision of the Interdepartmental Commission for the Prevention and Forecasting of Emergencies, the Agency for Monitoring and Forecasting Emergencies of the Ministry of Emergency Situations of Russia was established. This agency includes 25 different scientific institutions and organizations.

Thus, forecasting is the basic process that ensures the prevention of emergencies at the stage of early protection measures.

Forecasting and mitigation of the consequences of natural disasters

Indicators of the justifiability of forecasts and the prevention of natural emergencies are presented in Table 2.

The basis of the management system of the Unified State System for the Prevention and Liquidation of Emergency Situations in solving current tasks is the management bodies for civil defense and emergency situations (management bodies for GOChS) The Ministry of Emergency Situations of Russia: the central office of the Ministry, regional centers for civil defense, emergencies and elimination of consequences of natural disasters, as well as republican, regional, regional, city and district management bodies for GOChS.

To directly manage the liquidation of emergency situations, non—standard management bodies - operational headquarters and groups - are being created on the basis of the state emergency management bodies.

Table 2 - Indicators of justifiability of forecasts and warning. emergency situations of natural and man-made nature

Federal District	Reliability of long-term forecast of cyclical emergencies caused by spring snowfall,%	Justifiability of a medium-term emergency forecast for a month,%	Justifiability of a short-term emergency forecast,%	Operational daily forecast	
				Justifiability,%	Preventability,%
Far Eastern	90	73	81	83	72
Siberian	87	69	72	87	73
Uralsky	91	63	90	85	71
Privolzhsky	86	65	89	87	67
South	96	72	65	69	72
Northwest	95	67	92	91	60
Central	76	64	78	84	80
On average in the Russian Federation	90	68	81	84	71

The management of forces and means in the liquidation of natural and man-made disasters is carried out by the emergency commissions of republics, territories, regions, cities and districts from their permanent locations or from mobile control points.

The current stage of development of the Unified State System of Emergency Prevention and Response, including its territorial units, is characterized by a change in the priorities of this development in the direction from the tasks of emergency response and emergency response to the tasks of prevention, risk reduction and mitigation of the consequences of natural and man-made disasters. These priorities are reflected in the federal target program "Risk reduction and mitigation of the consequences of natural and man-made emergencies in the Russian Federation until 2005", approved by Decree of the Government of the Russian Federation No. 1098 of September 29, 1999.

The permanent day-to-day management body of the Unified State Emergency Prevention and Response System is the Crisis Management Center (CCCS) EMERCOM of Russia. The Center plans, organizes and implements measures for the management of forces and means in the aftermath of emergency situations, emergency rescue and other urgent work at the federal and regional levels.

So the essence and purpose of emergency monitoring and forecasting is to observe, control and anticipate dangerous processes and phenomena of nature and the technosphere that are sources of emergency situations, the dynamics of emergency situations, determining their scale in order to prevent and organize disaster response.

An important role in the monitoring and forecasting of emergency situations is played by the Ministry of Natural Resources of the Russian Federation, which provides general management of the state environmental monitoring system, as well as coordination of activities in the field of monitoring the state of the environment.

This ministry and its institutions organize and conduct:

- monitoring of sources of anthropogenic impact on the natural environment;

-monitoring of fauna and flora, terrestrial flora and fauna, including forests;

-monitoring of the aquatic environment of water management systems in places of water intake and wastewater discharge;

- monitoring and forecasting of hazardous geological processes, including three control subsystems: exogenous and endogenous geological processes and groundwater.

The Ministry of Health of the Russian Federation, through the territorial bodies of sanitary and epidemiological supervision, organizes and carries out social and hygienic monitoring and forecasting of the situation in this area.

Monitoring of the state of man—made facilities and the forecast of accidents are organized and carried out by federal supervisors - Gosgortehnadzor of Russia and Gosatomnadzor of Russia, as well as supervisory authorities within federal executive authorities. There are also supervisory bodies within the executive authorities of the constituent entities of the Russian Federation, and at enterprises and organizations — divisions for industrial safety of enterprises and organizations.

There are other types of monitoring and forecasting carried out for different types of objects, phenomena and processes, controlled ingredients and parameters for various types of hazards.

В основе структурного построения системы мониторинга и прогнозирования чрезвычайных ситуаций лежат принципы структурной организации министерств и ведомств, входящих в РСЧС, в соответствии с которыми вертикаль управления имеет три уровня: федеральный, региональный и территориальный.

Methodological guidance and coordination of the activities of the emergency monitoring and forecasting system at the federal level is carried out by the All—Russian Center for Monitoring and Forecasting of Natural and Man-made Emergencies of the Ministry of Emergency Situations of Russia (Center "Antistikhia"), in federal districts and subjects of the Russian Federation - regional and territorial centers for monitoring, laboratory control and forecasting of natural emergencies and of a technogenic nature (hereinafter referred to as regional and territorial monitoring centers).

The main tasks of regional and territorial monitoring centers are:

- collection, analysis and submission to the relevant state authorities of information on potential sources of emergency situations and the causes of their occurrence in the region, on the territory of;

- forecasting of emergency situations and their scale;

organizational and methodological guidance, coordination of activities and control of the functioning of the relevant links

- (elements) of the regional and territorial level of the emergency monitoring and forecasting system;

- organization and conduct of control laboratory analyses of the chemical-radiological and microbiological state of environmental objects, food, food, feed raw materials and water that pose a potential danger of emergency situations;

- creation and development of the emergency data bank, geoinformation system;

-organization of information exchange, coordination of activities and control of the functioning of territorial monitoring centers.

In general, the emergency monitoring and forecasting system represents a number of interdepartmental, departmental and territorial systems (subsystems, links, institutions, etc.), which include:

-The All-Russian Center for Monitoring and Forecasting of Natural and Man-made Emergencies of the Ministry of Emergency Situations of Russia; regional and territorial centers for monitoring natural and Man-made emergencies as part of the relevant GOChS management bodies;

-Monitoring and Laboratory Control Network of the Civil Defense of the Russian Federation;

-Unified State automated radiation monitoring system;

- Unified State environmental monitoring system;

-Special centers and institutions subordinate to the executive bodies of the subjects of the Russian Federation and local self-government bodies. All the relationships and interrelations of the above systems (subsystems) within the framework of the RSChS are defined by the relevant regulatory legal acts.

The technical basis of monitoring is made up of ground-based and aerospace facilities of the relevant ministries, departments, territorial authorities and organizations (enterprises) in accordance with their areas of responsibility.

At the same time, the main component is the ground-based means of the Monitoring and Laboratory Control Network of the Civil Defense of the Russian Federation, its main links subordinate to Roshydromet, the Ministry of Agriculture of Russia, the Ministry of Health of Russia and the Ministry of Health of Russia, as well as means of monitoring and diagnosing the state of potentially dangerous economic objects that are the main sources of man-made emergencies.

Space-based monitoring tools are mainly intended to identify and clarify the situation associated with forest fires, floods and other large-scale, dangerous natural phenomena and processes with insignificant dynamics.

Aviation means are used for the same purposes as space ones, as well as to obtain data on the state of the radiation situation, the situation in areas of large-scale destruction, the state of trunk pipelines and other conditions (road, snow, ice, etc.). They have broader capabilities, compared with space means, both in composition objects of observation, both in terms of efficiency and therefore are equipped with a number of relevant monitoring units, taking into account the areas of responsibility of the latter.

The general procedure for the functioning of the monitoring and forecasting system is determined by the Regulation on the System of Monitoring, Laboratory Control and Forecasting of Natural and Man—made Emergencies, approved by Order of the Ministry of Emergency Situations of Russia No. 483 of November 12, 2001, and its individual links and elements - by the provisions approved by the relevant federal ministries, departments, regional and territorial management bodies of the State Emergency Service.

Depending on the current situation, the scale of the predicted or emerging emergency situation, the emergency monitoring and forecasting system operates in the mode of daily activity, high-alert mode or emergency mode.

Forecasting of emergency situations includes a fairly wide range of tasks (objects or objects), the composition of which is determined by the goals and objectives of a managerial nature.

The most significant and urgently needed tasks (objects or objects) of forecasting are:

-the probability of occurrence of each of the sources of emergency situations (natural hazards, man-made accidents, environmental disasters, epidemics, epizootics, etc.) and, accordingly, the scale of emergency situations, the size of their zones;

-possible long-term consequences in the event of emergencies of certain types, scales, time intervals or their specific aggregates;

-the needs of forces and means for the elimination of predicted emergencies.

Appropriate methods are used to solve forecasting problems.

In general, the results of monitoring and forecasting are the initial basis for the development of long-term, medium-term and short-term targeted programs, plans, as well as for making appropriate decisions on the prevention and elimination of emergency situations.

In recent years, methods of planning measures for this problem based on forecasting and analysis of emergency risks have been actively introduced.

The main tasks of the analysis and forecasting of emergency risks are:

- identification and identification of possible sources of natural and man-made emergencies in the relevant territory;

-assessment of the probability (frequency) of occurrence of natural disasters, accidents, natural and man-made disasters (sources of emergency situations);

-forecasting of possible consequences of the impact of damaging factors, sources of emergency situations on the population and territories.

At the first stage, the sources of emergency situations are analyzed, as a result of the occurrence and development of which:

- the normal living conditions and activities of people in the relevant territory are significantly violated;

-human casualties or damage to the health of a large number of people are possible;

-significant material losses are possible;

-possible damage to the environment.

When identifying sources of emergency situations, the greatest attention is paid to potentially dangerous objects, assessing their technical condition and threats to the population living near them, as well as objects located in areas of possible adverse and dangerous natural phenomena and processes.

At the next stage, the probability of occurrence of natural disasters, accidents, natural and man-made disasters and the magnitude of possible damage from them, which characterize the risk of relevant emergencies, is assessed.

The forecast of the probability of accidents at economic facilities and their possible consequences is carried out by managers and specialists of these facilities.

The forecast of the risks of emergency situations caused by natural disasters, accidents, natural and man-made disasters possible in the territories of the subjects of the Russian Federation, municipalities, is carried out by the relevant territorial units (centers) SMP emergency.

The forecast of emergency risks in the country as a whole is carried out by the Ministry of Emergency Situations of Russia in cooperation with other federal executive authorities.

Without taking into account the data of monitoring and forecasting of emergency situations, it is impossible to plan the development of territories, make decisions on the construction of industrial and social facilities, develop programs and plans for the prevention and elimination of possible emergencies.

The effectiveness and quality of monitoring and forecasting largely depends on the effectiveness and quality of programs, plans and decision-making for the prevention and elimination of emergency situations.

The main tasks of federal and territorial executive authorities, local self-government bodies and organizations of various organizational and legal forms and forms of ownership involved in the organization of environmental monitoring, adverse and hazardous natural phenomena and processes and forecasting of natural and man-made emergencies are:

-creation, continuous improvement and development at all levels of appropriate systems (subsystems, complexes) of environmental monitoring and emergency forecasting;

-equipping organizations and institutions that monitor the environment and predict emergencies with modern technical means to solve the tasks assigned to them;

- coordination of the work of institutions and organizations at the local, territorial and federal levels to collect and exchange information on the results of monitoring and control over the state of the environment;

-coordination of the work of sectoral and territorial supervisory authorities on the collection and exchange of information on the results of monitoring and control of the situation at potentially hazardous facilities;

- creation of information and communication systems for solving the tasks of monitoring and forecasting emergencies;

- creation of an information base on the sources and scale of emergency situations;

- improvement of the regulatory framework for monitoring and forecasting emergencies;

- identification of bodies authorized to coordinate the work of institutions and organizations that solve the tasks of monitoring and forecasting emergencies;

-providing with the established frequency (in emergency cases immediately) the submission of environmental monitoring data and forecasting of emergency situations, relevant analyses of the growth of hazards and proposals for their reduction;

- timely consideration of the submitted environmental monitoring data and emergency forecasting, taking the necessary measures to reduce hazards, prevent emergencies, reduce their possible scale, protect the population and territories in case of their occurrence.

Questions for self-control

1) What is the prediction of an emergency. Deadlines. Forecasting goals.
2) What is monitoring
3) The justifiability of forecasts and the preventability of emergencies.
4) Federal bodies of supervision over the condition of hazardous facilities.
5) Tasks of regional and territorial monitoring centers.
6) Tasks of risk analysis and forecasting.

6 CLASSIFICATION AND ANALYSIS OF KNOWN MODELS AND METHODS OF FORECASTING MAN-MADE DAMAGE

Classification and analysis of known models and methods of forecasting man-made damage

Among the existing material and ideal models of various stages of the process of causing damage, almost all of their known classes can be distinguished. However, the use of physical models (full-scale and analog) is limited by the scope of suitability and high cost. Previously, they were mainly used to obtain statistical data (for example, when testing weapons of mass destruction). Now they are also used to test other models and generalize the results obtained on analogues, if the requirement of self-similarity (similarity) is met.

Ideal models are used much more widely, starting from intuitive (the method of accident scenarios) or semantic (dose—effect dependence) and ending with symbolic (mathematical and algorithmic) ones. The last group means the following.

Analytical models:

a) parametric formulas such as the M. Sadovsky equation for the pressure drop in the atmosphere or the K. Gauss model of the scattering of harmful substances in it;

b) balance (integral) models based on the integral laws of mass or energy balance and described by ordinary differential equations;

c) models based on the interpretation of the parameters of the state or energy and mass transfer in their original form and implemented by systems of partial differential equations.

Methods of simulation, statistical and numerical modeling

- based on the use of random distributions of parameters of a set of different models and taking into account their continuously changing factors.

As for the purpose of the listed models and methods, it is convenient to divide them into four stages of the formation of damaging factors and causing damage.

The models of such objects or processes are of the greatest interest, such as:

a) the source of the release of energy or harmful substances, the outflow of gaseous substances or the spreading of liquid substances over a solid surface;

b) propagation of energy or mass in the carrier medium or their inter-medium transfer;

c) boiling of liquefied gas, evaporation of superheated liquid, energy release and formation of fields of damaging factors

d) the recipient of these factors, protection against them, the defeat of the resource by a specific factor.

Risk management models

The emergence of ideas about risk. The concept of "risk", according to philologists, appeared in European languages quite late, at the end of the XV century. The main areas of its application were navigation and maritime trade. From about this time there was an intuitive distinction between danger and risk. One of the modern authors puts it this way: "There are two possibilities here. Or the possible damage is considered as a consequence of the decision, i.e. imputed to the decision. Then we are talking about the risk, namely the risk of the decision. Or it is considered that the causes of such damage are outside, i.e. they are imputed to the surrounding world. Then we are talking about danger." The development and colonization of the American continent required very risky and at the same time very profitable, if successful, enterprises. With the growth of human capabilities and the cost of decisions, the concept of risk has played an increasingly important role in culture and in science.

Marine insurance, which became widespread in the XVI century, apparently became one of the first risk management technologies. His strategy boils down to "smearing risk." For one trading house, the loss of an expedition equipped according to the state standard (in Spain, shortly after the Columbus expeditions, one was introduced) was unacceptable damage. However, the presence of an insurance fund created by a dozen such houses, in case of failure, made losses for the house that sent the expedition permissible. At the same time, an important psychological moment was also noted – the decisions taken by the committee usually turned out to be bolder than the "author's decisions". Note that so far we are talking about profit, damage, compensation – purely economic categories.

This historical example allows us to trace both the development of traditional issues related to risk, and fundamentally new moments that change the formulation of most tasks. Understanding these points led to the concept of risk management .

Let's go back to the example given.

Since the success of the expedition depends on many factors and a number of accidents, it is natural to assume that there may be not one, but several outcomes, for example N, and use the idea of probability. Let the ***i***-th outcome have probability pi and the income (or loss) from it will be x_i. Then the expected profit from the planned enterprise will be

$$S_i = \sum_{i=1}^{N} p_i x_i$$

Then, in order to compare two projects, you need to calculate the S_i value for each of them using this formula and choose the one for which it will be greater. This is the simplest version of the expected utility model, which plays a key role in modern decision theory.

Here there are two fundamentally different approaches, which can be conditionally called objective and subjective.

An objective approach begins with the essence of the problem and then goes back to the person, to the decisions made. Within the framework of this approach, goals are comprehended, principles corresponding to them are formulated and methods of project evaluation are proposed. If we follow this approach when analyzing the expedition and assume that the methodology used recommends proceeding from the ratio, then it is necessary to estimate the possible profits x_i, probabilities p_i as accurately as possible and make sure that all options (here there are N) are taken into account. An objective approach is usually used at the state level, as well as at the level of large corporations, when it comes to typical, fairly common risks, solutions, situations. It is often used in computer decision support systems.

The subjective approach comes from the person and goes back to the decisions made, to the risks arising as a result of them, etc. This approach is closely related to mathematical psychology. Its essence consists in offering formal procedures, criteria, and techniques that give approximately the same result in standard situations as the decision-maker.

The emergence of risks caused by long causal relationships. The production cycles involved substances whose effects on the biosphere and the human body have not been studied. A classic example is the insecticide DDT, which at one time was considered extremely effective, to which many insects, however, quickly adapted and which biologists now find even in the liver of penguins.

Modern technologies use substances present in the earth's crust in vanishingly small quantities, which can also lead to new risks. In particular, uranium is contained in the earth's crust in an amount of 0.005%. Naturally, in the course of evolution, protective mechanisms associated with many radiation damages did not arise in the biosphere. Therefore, protection issues should be a key element of the entire cycle of technologies related to the use of radioactive substances.

The interdisciplinary nature of risk. Not so long ago, the economy could be effectively managed according to the sectoral principle – to attribute the range of problems to the department of one ministry or state committee. The complication of the economic system, the increase in the product range, the increasing role of horizontal ties made this impossible. A similar process is observed today in the field of risk and security.

Global changes. Global problems become the source of many disasters and catastrophes. The latter owe much of their appearance to human activity. The current changes in the composition of the atmosphere, degradation of landscapes, and ocean pollution are considered by many experts as a "trigger" for global climate change. Behind this is the possibility of many natural disasters. On the other hand, global demographic processes of a huge scale are unfolding. According to various estimates, the population will grow in the coming decades and will stabilize at the level of 10-15 billion in the next century. a person, which will significantly increase the load on the biosphere. All this leads to the fact that many of the dangers and risks associated with the decisions taken have to be considered in a global context.

Risk concepts. Types of risk

Conceptual (ideological approaches to life safety) are associated with the concept of risk. With the development of the technosphere, human awareness of the nature of the dangers of ensuring the safety of life was considered within the framework of various conceptual approaches, among which the following should be highlighted.

The concept of absolute security (zero risk). This concept is also known as the theory of the highest reliability, according to which it was assumed that the necessary material costs for protective equipment, training of personnel, strict control over compliance with all norms and rules would ensure complete safety.

Deterministic approach (theory of normal accidents). This concept was developed in the 80s in a number of countries (USA, Netherlands, UK) and is being actively developed at the present time. In accordance with this approach, the impossibility of ensuring absolute security is recognized. Within the framework of this concept, in particular, the risk of major accidents with catastrophic consequences is considered.

According to classical concepts, the dependence of the probability density of accidents (p) on the amount of damage caused (u) has the form

$$p(u) \approx e^{\frac{-u^2}{\sigma^2}}$$

where σ is the variance of a random variable, in this case the number of accidents. Based on this dependence, it can be assumed, for example, that about 90% of minor accidents occur (so-called design accidents), about 9% of major accidents (out-of-design accidents), and about 1% occur in hypothetical accidents, the probability of which is extremely low, and therefore it is not advisable to take them into account. So, until relatively recently, the potential danger of accidents at nuclear power plants was assessed.

Currently, the so-called "theory of self-organized criticality" is being developed in mathematical physics, according to which, for large values of u, the probability density has the form

$$p(u) \approx e^{-\beta} .$$

where β=1. This means that catastrophic accidents, although rare, but their probability is not negligible, and it is unacceptable to ignore their possibility.

The main principle of the deterministic approach is, therefore, to determine an acceptable risk corresponding on the one hand to a practically achievable level of security (the risk is as low as possible), and on the other hand to a reasonably achievable level of security from the point of view of a cost-profitable balance. In other words, "security is how much you are willing to pay for it."

A combined approach. This approach recognizes the inevitability of dangerous accidents and accidents, but assumes minimizing them based on a thorough analysis of hazards in the design of systems, priority financing of safety measures, careful compliance with safety legislation, compliance with rules and instructions.

Definition of risk. Types of risk. As mentioned above, risk is a quantitative assessment of danger. Currently, there is no single formula for determining risk, although a general approach to risk assessment can be expressed using the formula

{Risk} = {probability of event}{significance of event}

Here, the significance of the event is usually assumed to be the damage that can be caused as a result of the implementation of an undesirable event.

Most often, risk is defined as the frequency or probability of occurrence of an event. It can be calculated as the frequency of hazards in relation to their possible number, (or the ratio of the number of undesirable events to the total number of events)

$$R = \frac{N(t)}{Q(t)} .$$

Различают несколько видов рисков: индивидуальный, социальный, технический, экологический, экономический.

Individual risk is determined by the probability of the realization of potential hazards in the event of a dangerous situation.

$$R=P(t) / N(f),$$

where P(t) is the number of injured (dead) per unit of time t (more often per year), N(f) is the total number of people exposed to risk factor *f* per unit of time *t*.

Let's say, for example, the number of employees in the chemical industry is 750 thousand people. Every year, an average of 150 people die as a result of accidents at chemical industry enterprises.

Then we get the value of individual risk as the average number of deaths per person per year:

$R=150 / 750000 =2\cdot10^{-4}$

Table 3 - Individual risk

Type of danger	Individual risk
Falling from a height	9×10^{-5}
Fires	4×10^{-5}
Drowning	3×10^{-5}
Poisoning	2×10^{-5}
Firearms	1×10^{-5}
Machine tools	1×10^{-5}
Road transport	3×10^{-4}
Water transport	9×10^{-6}
Air transport	9×10^{-6}
Railway	4×10^{-7}
Falling objects	6×10^{-6}
Electric current	6×10^{-6}
Lightning	5×10^{-7}
Nuclear energy	2×10^{-10}
General risk of death as a result of an accident	6×10^{-4}
Production	$1{,}6\times10^{-4}$
Traffic accident	$2{,}5\times10^{-4}$
Poisoning	$2{,}7\times10^{-4}$
Drownings	$8{,}0\times10^{-5}$
Fires	$4{,}0\times10^{-5}$

Individual risk characterizes, thus, the danger of a certain kind for an individual.

Individual risk can be voluntary and forced. Voluntary risk is caused by human activity on a voluntary basis, a person is usually exposed to forced risk as part of a part of society (for example, living in ecologically unfavorable regions or near sources of increased danger).

Social risk characterizes the scale and severity of the negative consequences of an emergency, often expressed in the number of dead and wounded. In other words, social risk is the dependence of the frequency of events that cause the defeat of a certain number of people on this number of people. Social risk *Rc = f(N)* is introduced as some characteristic of the scale of possible accidents.

It is possible to note such types of risks as **technical risk**, which is an indicator of the reliability of the elements of the technosphere, environmental risk, which characterizes the scale of environmental disaster, catastrophe, violations of the stability of ecological systems, **economic risk**, determined by the ratio of benefits and harm that society receives from the type of activity in question.

Let's take a closer look at the economic risk in the context of ensuring the safety of life. It can be written as

$$R = B \cdot 100\% / P ,$$

where B is harm, P is benefit, and B = Zb + Y ,

where Zb is the cost of achieving a given level of security,

Y – damage caused to society, nature due to insufficient protection.

The benefit is defined as

The benefit is defined as

$$P = D - Zp - Zb - U,$$

where Zp is the main production costs, D is the total income.

Naturally, N > 0 must be executed. Thus, ensuring the safety of life is economically justified if

D – (Zp + Zb) > U.

From here we logically approach the concept of acceptable risk.

Acceptable risk combines the concepts of individual, social, technical, environmental and economic risks and represents a compromise between an acceptable level of security and the economic possibilities of achieving it. The material costs of ensuring security, increasing the cost of products, ultimately fall on society, worsening the quality of life of the population (an increase in social risk). Thus, reducing all types of risks, we must not forget what it will cost society, and what the social risk will be as a result.

The risk, therefore, is acceptable if its magnitude (probability of realization) is so insignificant that for the sake of the benefits received in the form of material or social benefits, a person or society as a whole is willing to take the risk.

It follows from the above that we can talk about acceptable individual risk, acceptable technical risk, acceptable environmental risk, etc. In developed countries, the maximum acceptable individual risk (per year) is considered to be a risk equal to 10^{-6}, and negligibly small – 10^{-8}. (For environmental risk, the maximum acceptable value corresponds to a state where 5% may suffer biogeocenosis.)

Questions for self-control

1) List the analytical models for predicting man-made damage
2) Simulation method

3) Statistical modeling method
4) Risk management models
5) Interdisciplinary nature of risk
6) The concept of absolute security
7) Deterministic approach
8) Combined approach
9) Definition of risk. Types of risk.
10) Individual risk
11) Social risk
12) Acceptable risk.

7 RISK MANAGEMENT

Risk management. In connection with the adoption of the concept of acceptable risk, corresponding to both a deterministic and a combined approach to security, the tasks of risk assessment and risk management arise.

Risk assessment is an analysis of the origin (occurrence) and extent of risk in a particular situation.

Risk management should be understood as the analysis of a risk situation, the development and justification of a management decision, often in the form of a legal act aimed at minimizing risk. The approximate sequence of risk assessment may be as follows:

- primary identification (recognition) dangers;
- description of the source of danger and related damage;
- risk assessment under normal operating conditions;
- risk assessment of possible hypothetical accidents at work, during storage and transportation of hazardous substances;
- investigation of possible scenarios for the development of an accident;
- statistical estimates and probabilistic risk analysis.

Physical and computer modeling of risk

Many accidents and natural disasters – from the collision of comet Shoemaker–Levy with Jupiter to the Chernobyl accident – demonstrate a number of effects, phenomena, mechanisms previously unknown to science. This, at first glance, devalues the research previously conducted in these areas, and calls into question the very value of mathematical and other modeling.

There is a fundamental methodological point here – for many accidents and crisis situations, a full-scale field experiment is fundamentally impossible. In addition, the economy, society, and technosphere are unique, irreversibly developing systems and give us only fragmentary and approximate knowledge, which makes it difficult to move from formal (general) mathematical models to concrete ones. Therefore, it is necessary to investigate individual mechanisms and processes that play a key role in disasters on simpler model objects (often even belonging to another field of science) and then create a whole from these fragments.

The opportunity to set up a computer experiment and conduct a sufficiently detailed simulation significantly expanded the capabilities of researchers. You can trace dozens and hundreds of computer disasters to find ways to prevent real ones. In addition, there are two important relationships. First, computer models help to create training programs, simulators, complexes for training personnel, helping to act effectively in crisis situations. Secondly, they often show what information and to what extent should be collected.

At the end of the 90s of the XX century, the State Scientific and Technical Program "Safety" was implemented in Russia. The analysis of the available mathematical models carried out within its framework showed that their arsenal is clearly insufficient. The mutual linking of these models, which makes it possible to assemble a whole from parts, a model of an accident or catastrophe, is also still imperfect. However, without such models, which are much closer to fundamental science than to engineering developments, the risk of decisions would be much greater – real threats would be exacerbated by our ignorance.

Risk management technologies are likely to be the focus of attention of researchers and managers in the next century. Mathematical models will play a dual role in this case. On the one hand, they will allow you to evaluate a number of decisions taken. On the other hand, they will express the existing ideas about risks, strategies and methods used in a clear, clear and formalized form that allows for verification, criticism and correction. The fundamental changes in the field of security that have occurred in recent decades make the problem of building a new generation of models urgent now.

The second problem is related to probabilities appearing in formulas, or in more complex functionals. On the one hand, the objects under study are too complex to be able to estimate the corresponding probabilities theoretically (for example, as in the case of a dice). On the other hand, if we are talking about major catastrophic events, they are usually rare, and therefore statistics are not enough to assess the probabilities of *pi*, and in the case of new technologies, it simply does not exist. The main approach here is to judge the probability of disasters based on the results of monitoring, according to statistics of small events of the same nature.

For example, according to data on seismic activity, on "small earthquakes", it is necessary to judge the frequency of destructive earthquakes in a given region.

In addition, there is a problem associated with the uniqueness of the situation or with the fact that the decisions taken can fundamentally change it. That is, the winnings, probabilities, and decision-making conditions for the second attempt to implement a project may turn out to be completely different from those for the first. Conditionally, this can be called the solution effect.

Finally, when ensuring security, they often encounter the paradox of the planner, when the chosen strategy turns out to be optimal in a 5-10-year perspective, satisfactory at times of 15-20 years and unacceptable if we keep in mind a longer perspective. The problem of dismantling NPP power units, updating the pipeline network, ensuring the safety of dams and reservoirs provide numerous examples that it is not always possible to "postpone for tomorrow" safety measures. Usually "tomorrow" comes much faster than expected.

Risk management levels

In some approximation, risk management models can be divided into several levels: global, state, regional-industry, scenario-object level.

1) Global level

Since global problems are the sources of many natural and man-made disasters, risk management largely depends on the parameters of the world, the biosphere, the technosphere as a single global system.

For example, the threat of famine, epidemics, ethnic conflicts in various regions of the world is directly related to the value of gross domestic product per capita in the countries that are located in this territory. This value depends on how fast the population is growing in them. The latter is determined by their level of development, etc.

This circle of cause-and-effect relationships reflects the models of world dynamics that appeared in the 70s. Apparently, the first model of this class was built by J. Forrester. It featured variables such as "production", "pollution", "population", etc., characterizing the world as a whole. R. Meadows' book "Limits of Growth" had a great influence on society, which also discusses possible options for the development of civilization with various selected strategies and control actions. Models of this type have played an important role in realizing that the previous trajectory of expanded reproduction, "ever more complete satisfaction of growing needs" has reached a dead end. They have been widely discussed in various environmental publications. However, they can also play an important role in risk management theory.

Life expectancy, mortality statistics, social consequences of disasters and catastrophes, the harm caused by technology to nature differ significantly in developed and developing countries. There are diseases of rich and diseases of poor states. With one strategy for the development of the world community as a whole, these differences will be smoothed out, with another – they will increase (which is happening now). Currently, the ideas of sustainable development have gained great popularity. One of the elements of this strategy is to mitigate the consequences of possible disasters and catastrophes. A concrete analysis of the entire proposed strategy for sustainable development and the disaster-related block is extremely important. Obviously, the price for changing the course of development of civilization will be great. But in order to seriously talk about this concept, it is important to evaluate it and understand who and what share of the costs will be borne. Without this, such projects will remain good wishes.

Another class of models of the same level is associated with the impact of individual catastrophes on the future of mankind. One of the most striking examples of such models is the global model of the atmosphere, ocean, biosphere, built by a team of researchers from the Computing Center of the Academy of Sciences under the leadership of N.N. Moiseev. This model made it possible to assess the climatic consequences of a full-scale exchange of nuclear strikes. The mathematical model showed that the release of a significant amount of dust and soot into the atmosphere can lead to a "nuclear night" or even a "nuclear winter", which can change the global circulation of the atmosphere for a long time and destroy the biosphere. This model also made it possible to forecast climate changes caused by an increase in the content of carbon dioxide in the atmosphere.

Models of this type have become widely used in connection with the problem of transboundary transport – an assessment of which countries and what contribution they make to air or water pollution in a given territory and what costs can be imposed on them. The consequences of giant volcanic eruptions, the fall of large asteroids to Earth were also analyzed in the framework of such descriptions.

A number of impacts that are of a different nature are also of global importance. In particular, the set of priority problems that the world community has to solve depends fundamentally on the size of the world's population. Therefore, global demographic models are also directly related to risk and security. Apparently, the controlling influences here can be measures aimed at introducing more effective technologies, improving the level of education and changing stereotypes of mass consciousness. Models describing global epidemics, in particular, the AIDS epidemic, also reflect the risks common to all mankind.

Many modern dangerous technologies and the risks associated with them have been brought to life by the military, ideological, ethnic, and geopolitical confrontation of countries and regions. The number of victims of such a confrontation, even in our time, is incomparable with the number of deaths as a result of accidents and natural disasters. For example, in 1994 in Rwanda, at least a million people belonging to another nationality died at the hands of the regime that came to power, which included representatives of one nationality. Therefore, a number of strategic stability models can certainly be attributed to global risk management models.

2) State level

Until recently, macroeconomic models served as key tools for forecasting the country's development and planning for various periods. In such models, the consequences of disasters and catastrophes were ignored or taken into account as small corrections. However, the situation has changed in recent years and it is likely that risk and uncertainty factors will become an integral attribute of these models. There are several reasons for this.

1) The smaller the gross domestic product (GDP), the greater its share, as statistics show, goes to eliminate the consequences of disasters and natural disasters. If in developed countries this share is 3 to 5%, then the well-known earthquake in

Nicaragua caused damage exceeding the entire GDP of the country. As you know, Russia's GDP has declined significantly in the last decade. If in the 80s the country ranked second in the world in this indicator, today it is on the 57th position in terms of GDP per capita. On the other hand, the number of accidents is growing rapidly. Extrapolation of such growth for the next decade has shown that this share can reach a quarter of the entire state budget. Now a significant reduction in the number of accidents and mitigation of the consequences of disasters can result in an increase in the budget by amounts exceeding the results of many stabilization and economic reform plans.

2) The increase in the scale of disasters makes them an increasingly noticeable factor in economic life. It is enough to recall the amount of expenses of the Soviet Union for the elimination of the consequences of the Chernobyl accident.

3) The resilience of society in relation to disasters directly depends on the state of the economy. It also, in the case of a weak economy, directly depends on the global conjuncture. Its change can be compared with the consequences of a major war. This means new dangers for people in the natural and man-made spheres.

4) Global climate changes have led to the fact that harvests in many areas of risky farming have become much less stable (droughts in some places, heavy rains and floods in others, rising water levels, etc.).

The last three factors lead to the fact that the variables traditional for macroeconomics (the cost of fixed assets, budget revenues, etc.) become random variables. This leads to the need to develop a kind of "macroeconomics of risk".

Another class of models is associated with technological policy at the national level, with changes in structural policy. A typical example is the development strategy of the fuel and energy complex. There is a wide range of alternatives here. From the complete abandonment of nuclear energy and the risks associated with it (this path is now being followed in Sweden), to its accelerated development (in France, nuclear power plants provide more than 70% of energy). Each of the methods of industrial energy production has its drawbacks and carries its own dangers (pollution of the environment by acid rain and consumption of irreplaceable resources for thermal power plants, flooding of large territories, complex and expensive technologies for maintaining dams in working condition for hydroelectric power plants). Solutions in this area should be based on models of the "resource management" type. At the same time, it is necessary to manage not only financial flows and material resources, but also the risks associated with them.

Another class of models is related to the structure of public administration. Many large states have a federal structure. The question arises about the interaction of the subjects of the federation in the field of risk and security. A typical example is a crop failure or natural disasters that hit a number of regions. The obvious idea is to insure territories, transfer payments that are sent by prosperous entities to the victims. Mathematical modeling in this important area has just begun. At the same time, we must be aware that regional insurance and transfers will be effective if there are few disasters of this scale, and there are many prosperous subjects.

The long chains of cause-and-effect relationships mentioned above can be extremely important at characteristic times of tens of years. Such connections include social ones related to pension provision (recall the words of one Roman emperor that the basis of the greatness and power of Rome is its attitude to veterans), with the help of victims during disasters. The pension schemes discussed above – traditional objects of actuarial mathematics – proceed from purely economic considerations. This seems insufficient.

Here we need models that would take into account psychological and socio-psychological factors. In fact, should the state only feed and warm the victim and provide him with medical care, or also take care of his further employment or housing provision? Different countries have different policies. It is determined not only by the standard of living of society, but also by traditions, socio-psychological factors, and the role of the state in human life. By controlling the level of social guarantees, we control the attitude of a large stratum of people to system-forming values.

A large class of mathematical models can be called federal-level monitoring models. These models are the basis of all information collection and analysis systems, forecasting systems, on the basis of which decisions should be made.

Space surveillance systems, a network of seismic stations and weather stations, etc. they are determined by what information and to what extent we need it. This is dictated by the ideas about natural disasters and catastrophes that we have. And they, in turn, rely on mathematical models. A lot of progress has been made in modeling a number of disasters, which is likely to lead to success in predicting hazards.

3) Regional industry level

Models of this level are particularly important, since the main burden of work on threat prevention and the greatest opportunities for disaster mitigation relate to it. Civil protection in Russia is provided by a distributed system of forces, means, management bodies, and information centers. Risk management models are designed for these structures.

First of all, these are economic models of risk management for territorial production complexes that the subjects of the federation have.

The purpose of these models is to assess the dangers of existing facilities, measures to prevent accidents and catastrophes and build a system of priorities. At the same time, models should also give estimates of possible damage if certain measures are not taken. The work on the draft Federal Program for the Prediction and Prevention of Accidents, Catastrophes and Natural Disasters and Mitigation of Their Consequences has shown an unsatisfactory state of affairs in terms of priorities. The total amount of measures announced by the subjects exceeded 10% of the state budget. This means that urgent, priority projects were not separated from secondary ones. Models and decision support systems would be very useful here.

Within the industry, these models can be conditionally attributed to the class of models "optimal equipment upgrade mode".

Conventional models of this type are focused only on economic efficiency. This is not enough to manage the risk. These models should reflect the state of industrial facilities and infrastructure in the industry, give a forecast of the expected number of risks and accidents and allow assessing the economic effect of various strategies to increase the sustainability of the industry. The traditional task here is to determine what proportion of equipment and infrastructure should be upgraded at a given level of investment, optimizing both economic efficiency and security.

In addition, the regional level usually has its own monitoring systems, its own sources of danger: environmental pollution with various hazardous chemicals, the dangers of floods or epidemics characteristic of the region, etc. There is a large set of models already built and tested, and the task is often reduced to their reasonable choice and binding to the realities of the region.

4) Scenario object level

Each dangerous object, as a rule, has its own characteristics, its own set of design and beyond-design accidents and catastrophes. Modern mathematical modeling tools for most of them (explosions, spills of highly toxic substances, etc.) allow us to find out a typical accident scenario, a characteristic picture of its different stages. On this basis, it is usually easier to plan rescue operations. Models allow, as a rule, to find out the "vulnerability windows" of those enterprises or territories whose security should be taken care of first. In many specific cases, the analysis of these models helps to understand how to build a monitoring system at a given facility.

Uncertainty and risk. Assessment of the risk of decisions taken or danger, i.e. information about the probabilities of various possible outcomes and possible damages, indicates a very high level of knowledge about the studied objects, technologies, solutions. In many cases, modern science is not at the level that allows us to talk about risk. Bearing in mind such disasters, catastrophes, opportunities, we are in a situation of uncertainty.

The difference between risk and uncertainty dates back to the beginning of the century, to the concept of F. Knight, who considered the basics of economic theory. "The practical difference between risk and uncertainty categories is that in the first case, the distribution of results in the group is known (which is achieved by a priori calculations or studying statistics of previous experience), and in the second – not. This is most often caused by the inability to group cases, since the situations under consideration are largely unique.

The best example of uncertainty is associated with making judgments or forming opinions about the future development of events; it is these opinions (and not scientific knowledge at all) that have a decisive influence on our behavior," he writes in his classic work. A simple mathematical example. Let there be 10 balls in the urn, 9 red and one black. Then the risk of drawing a black ball has a probability of 1/10. If we do not know how many and which balls are in the urn, then we are in a state of uncertainty.

Unfortunately, with regard to many products of genetic engineering, biotechnology, the chemical industry, as well as many new technologies, we are dealing not with risk, but with uncertainty. However, the experience of recent decades shows that a number of dangers that we are unaware of today may require greater concerted efforts both at the national and global levels. In fact, one of the main tasks of security and risk science is to ensure the rapid passage of the path from uncertainty to risk, to eliminate the need to act at random, by trial and error. This is all the more important, since many risks can be reasonably managed, but uncertainty cannot.

Questions for self-control

1) What is the risk assessment?
2) Physical and computer modeling of risk
3) List the levels of risk management
4) Global level of risk management
5) State level of risk management
6) Regional and industry level of risk management
7) Scenario-object level of risk management

8 BASIC PRINCIPLES OF SYSTEM ANALYSIS AND MODELING OF DAMAGE FROM MAN-MADE ACCIDENTS AND CATASTROPHES. ASSESSMENT OF THE EMERGENCY SITUATION

Basic principles of system analysis

After considering with the help of cause-and-effect diagrams, failure trees, functional networks of circumstances and conditions of occurrence of accidents in the technosphere, it seems logical to proceed to a systematic analysis and modeling of the processes themselves that lead to the appearance of the corresponding damage. At the same time, it is advisable to focus on the study of the patterns of release, distribution, transformation and destructive effects of emergency flows of energy and matter.

The main stages and components of the formation of technogenic damage

According to the statistics of modern accidents, catastrophes and accidents with people, the greatest man-made damage to human, material and natural resources is caused by fires, traffic accidents, explosions and destruction of buildings. The majority of man-made accidents are caused by the uncontrolled release of kinetic energy of moving machines and mechanisms, as well as potential or chemical energy accumulated in high-pressure vessels and fuel-air mixtures, condensed explosives, toxic liquids and other harmful substances.

The main damaging factors of accidents and man - made disasters usually include:

a) thermal: it includes thermal radiation, a "blow" by a flame or cryogenic substance; the effect of the thermal factor is 56% of the causes of the destructive effect;

b) high explosive: implements crushing, propellant or fragmentation effects of moving bodies, including explosion products — is about 29%,

c) aggressive or toxic properties of harmful substances or accident-chemically hazardous substances (AHS) - they cause about 10% damage.

The ultimate goal of system analysis and modeling of the process of energy and harmful substance propagation is the construction of fields of spatiotemporal distribution of their flux density or concentration.

A detailed consideration of man-made accidents should be carried out after the decomposition of the entire process of formation of damaging factors that damage human and material resources. Decomposition according to the formal "life cycle" model is appropriate here.

The following four stages or stages can be distinguished:

1) the release of energy accumulated in the human-machine system or reserves of harmful substances due to an accident that occurred there;

2) uncontrolled distribution (translation) of their streams into a new environment for them and moving in it;

3) their further physical and chemical transformation (transformation) with additional energy release and transition to a new aggregate or phase state;

4) the destructive effect (adsorption) of primary flows and /or damaging factors induced by them on objects that are not protected from them.

Let's look at these stages in more detail.

The first stage

The characteristics of the first stage, i.e. the process of releasing emergency-hazardous energy and substances accumulated in technosphere objects, consist of answers to the following questions:

a) what is released;

6) from where or from what it expires;

c) how it happened or is happening. At the same time, the main attention in answering each of them will be paid responsibly to the physicochemical properties of the substance or energy, their released amount and the dynamics (change in time) of the process under consideration.

The following basic answers to these questions are possible:

a) solid or substance — gaseous, liquid, gas—droplet or powdery, which can be inert and non-inert or changing and not changing its aggregate state after release, as well as energy - in the form of moving bodies or a stream of invisible particles-waves;

b) from a generator (compressor, pump, energy source) or battery (capacity) — through a crack or hole formed in them;

c) almost instantaneously (salvo discharge), continuously — with constant or variable flow and occasionally — regularly or randomly.

The purpose of system analysis and modeling of this stage can be to predict its parameters such as the amount of a harmful substance suddenly or gradually released, the intensity and duration of its expiration, as well as the density of the flow of bodies or particles and the intensity of electromagnetic fields or ionizing radiation.

The second stage.

The peculiarities of the course of the second stage of the process under consideration, i.e. the spread of dangerous flows, are due to both the factors just listed and the specifics of the space filled with matter or located between the energy source and the object exposed to it. Most often, this space can be three—dimensional (atmosphere, reservoir, soil), have a filling - heterogeneous or homogeneous, stationary or mobile (carrier medium), have virtually infinite dimensions or be limited by another medium capable of absorbing or reflecting energy or matter flows.

Taking into account this circumstance, various combinations of factors essential for the processes of energy and mass transfer and flow formation are possible, leading to various scenarios, starting with the spreading of liquid substances over a solid surface and ending with filling the entire space with a mixture of aerosol, gas and /or liquid.

Consider, for example, scenarios related to the spread of chemicals in the air. The complexity of the model here can be different, and it largely depends on the assumptions made. In particular, the following variants of the problem statement are possible.

1. The assumption of the immobility of the atmosphere is accepted. In this case, the main features of the spread of gaseous substances can be distinguished. They usually manifest themselves in the formation of either a cloud (for a volley release of gases) or a plume (for their continuous outflow), which then behave accordingly as follows:

a) creep over the surface or gradually approach it (heavy gases);

b) touch the ground or spread parallel to the surface (gases whose density is close to the density of air;

c) rise in the form of a mushroom or an expanding cone, the cross-sections of which are called "thermals" ("thermic" is an intensively mixed formation with light streams rising inside and falling due to cooling by denser ambient gases (light gases).

2. The mobility of the atmosphere as a carrier medium and the nature of its underlying surface are taken into account.

The mobility of the atmosphere is characterized by wind speed, transport speed, vertical stability.

The nature of the underlying surface is determined by the terrain, surface roughness.

These factors slightly modify the process of cloud propagation. This usually leads to the drift of a plume or cloud in the atmosphere with a gradual change in their height and shape, approximately as shown in Fig. 1. The reasons for this are the action of Archimedean and forces, as well as the erosion of the surface of these formations due to friction on the surface of the earth and turbulent scattering of gases in the process of so—called atmospheric diffusion (turbulent diffusion).

The amount of friction on the earth's surface usually depends on the size of buildings, ravines, trees, bushes and other natural roughnesses.

The influence of the atmosphere is determined by the direction and speed of the flows circulating in it, including the flow of thermal energy. To account for such an influence in mathematical modeling, six classes of atmospheric stability are usually used: highly unstable with a predominance of convection, moderately unstable, weakly unstable atmosphere, neutral stratification, i.e. isothermy, weakly stable with inversion, moderately stable.

As other initial data, various scenarios and factors are used, as well as quantitative characteristics obtained during the study of the first stage of the process of formation of damaging factors.

The third stage.

The transformation of emergency released energy flows and stocks of harmful substances depends on a large number of the above factors and their probable combinations. However, the dominant position among them is occupied by those physico-chemical properties of the emission products that have spread in the new environment, which characterize their mutual inertia. Otherwise, in the volumes of space formed or changed under their influence, not only various phase transitions of the "boiling — evaporation" type are possible, but also chemical transformations in the form of gorenje or explosion, accompanied by a large release of energy.

Two cases should be highlighted here:

-large spills of emergency chemical hazardous substances,

-filling them with pairs of relatively small volumes of airspace.

In both cases, air-fuel mixtures capable of transformation in one or more of the above-mentioned forms ("boiling - evaporation", "gorenje/explosion") can be created. For example, a salvo release of a significant amount of liquefied petroleum gas is accompanied by almost instantaneous evaporation with the formation of a mixture that can then (after contact with open fire) explode or burn intensively.

It is necessary to pay attention to the fundamental difference between two such modes of physicochemical transformation with high energy release, as gorenje (deflagration) and vryv (detonation).

In addition to a much higher (on average up to 2 orders of magnitude) velocity of detonation propagation, its front is practically flat, not turbulent, as in gorenje, surface and is characterized by an order of magnitude greater pressure gradient in the compression waves generated by detonation (about 2, not 0.1 MPa).

It is the latter feature that explains the enormous destructive effect of the explosion of fuel-air mixtures.

The purpose of the system analysis and modeling of this stage of the process under consideration is to predict not only the nature of the transformation of harmful substances dispersed as a result of the accident, but also the damaging factors caused by the subsequent transformation in a new environment for them.

The fourth stage.

The fourth stage and the ultimate goal of the entire study of the process of causing man-made damage is to study the damaging effects of primary and secondary products of accidental release on unprotected human, material and natural resources (actually causing damage). The main initial data used in this case are the parameters of a) damaging factors (pressure drop in the front of the air shock wave, concentration of toxic substances, intensity of thermal and ionizing radiation, flux density and kinetic energy of moving fragments), b) potential victims (durability and survivability of specific objects, taking into account the frequency or long-term harmful effects on them and the quality of rescue operations).

The damage itself from such an impact should be divided into two types:

a) direct or direct damage caused by the loss of integrity or useful properties of a particular object, and

b) indirect, caused by the destruction of connections between it and other objects.

Assessment of the emergency situation

Forecasting and assessment of the situation in emergency situations are carried out for the early adoption of measures to prevent emergencies, mitigate their consequences, determine the forces and means necessary to eliminate the consequences of accidents, catastrophes and natural disasters.

The purpose of forecasting and assessing the consequences of emergency situations is to determine the size of the emergency zone, the degree of destruction of buildings and structures, as well as losses among the personnel of the facility and the population.

As a rule, this work is carried out in three stages.

At the first stage, the consequences of the most probable natural and man-made emergencies are predicted, carried out for average statistical conditions (average annual weather conditions; average distribution of the population in houses, on the street, in transport, at work, etc.; average population density, etc.). This stage of work is carried out before emergencies occur.

At the second stage, the consequences are predicted and the situation is assessed immediately after the occurrence of the source of emergency situations according to updated data (the time of the emergency, meteorological conditions at that moment, etc.).

At the third stage, the results of forecasting and the actual situation are adjusted according to the intelligence data preceding the emergency rescue and other urgent work.

This manual discusses methods for predicting the consequences of dangerous phenomena corresponding to the first stage.

Regardless of the source of the emergency situation, there are six main damaging factors affecting people, animals, the environment, engineering and technical structures, etc. These are:

-baric effects (explosions of explosives, gas-air clouds, technological pressure vessels, explosions of conventional and nuclear weapons of mass destruction, etc.);

-thermal effects (thermal radiation in man-made and natural fires, fireball, nuclear explosion, etc.);

-toxic effects (man-made accidents at chemically hazardous industries, plume of combustion products during fires, use of chemical weapons, emissions of toxic gases during volcanic eruptions, etc.); - radiation effects (man-made accidents at radiation-hazardous facilities, nuclear explosions, etc.);

- mechanical effects (fragments, building collapses, gorenjesus, etc.);

- radiation effects (man-made accidents at radiation-hazardous facilities, nuclear explosions, etc.);

- mechanical effects (fragments, collapses of buildings, mudslides, landslides, etc.);

- biological impact (epidemics, bacteriological weapons, etc.).

When predicting the consequences of dangerous phenomena, as a rule, deterministic or probabilistic methods are used.

In deterministic forecasting methods, a certain amount of the negative impact of the damaging factor of the source of the emergency situation corresponds to a very specific degree of damage to people, engineering structures, etc.

For example, the excess pressure at the front of the $\Delta P_f = 10$ kPa is assumed to be safe for humans.

If the excess pressure at the front of the $\Delta P_f > 100$ kPa, a fatal defeat of people will take place.

In case of toxic exposure, such values are threshold toxodosis and lethal toxodosis.

The area bounded by a line corresponding to a certain degree of negative impact is called the impact zone of this level (lethal, medium, threshold, etc.).

In fact, when exposed to the same dose of negative impact on a sufficiently large number of people, buildings and structures, components of the environment, etc., the damaging effect will be different and the above values correspond to the mathematical expectation of this degree of negative impact.

In other words, the negative impact of damaging factors is probabilistic. The magnitude of the probability of defeat (the effect of defeat) of the P_{por} is measured in fractions of one or percent and is determined, as a rule, by the Gaussian function (error function) through the "probit function" of the Pr.

$$P_{por} = f(Pr(D)) ,$$
$$Pr = a + \ln D,$$

where f- Gaussian function;

a, b - constants depending on the type and parameters of the negative impact;

D - the dose of negative impact, equal to:

$D = q^n \tau$ – under thermal influence,

$D = f(\Delta P_f I_+)$ – with baric exposure,

$D = C^n \tau$ – with toxic effects

$D = D_{ef}$ – in case of radiation exposure.

Here q - is the heat flux density,

τ - exposure time;

ΔP_f - excess pressure at the shock wave front;

I_+ - shock wave compression phase pulse;

C - concentration, toxicant;

$D_{Эф}$ - effective dose of ionizing radiation;

n - the exponent.

The main activities of the RSChS on monitoring and forecasting of emergency situations

1. creation of a data bank on emergency sources
2. conducting observations of emergency sources
3. conducting observations of emergency sources
4. Emergency forecasting
5. providing public administration bodies with information about the threat of an emergency.

The main objectives of emergency monitoring and forecasting

-risk reduction and mitigation of the consequences of natural and man-made emergencies;

- identification of places of possible manifestation of emergency sources (zones of potential danger);

-early determination of the location, time and parameters of emergency sources;

-early determination of the place, time and consequences (scale) of an emergency;

- organization of the examination of engineering protective structures

-organization of active actions on emergency sources, in order to suppress them, localize and control parameters.

Questions for self-control

1) What are the main stages and components of the formation of man-made damage.

2) List the main damaging factors.

3) Accident stages.
4) The assumption of the immobility of the atmosphere.
5) The influence of the nature of the underlying surface.
6) Assessment of the emergency situation.

9 EARTHQUAKE FORECASTING

There are quite a lot of earthquake precursors. Let's consider the most significant ones.

Seismic. Usually, the rate of stress accumulation does not exceed 10 N / cm^2 per year, and the greater the magnitude of the earthquake and the energy released, the longer the interval between strong earthquakes. D.I. Musketov expressed the idea that areas of alpine folding (for example, the Caucasus) are characterized by a greater frequency, but less earthquake strength than for young mountain areas that have arisen in place of platforms (for example, for the Tien Shan).

Geophysical. Accurate measurements of deformations and slopes of the earth's surface using deformers indicate that the deformation rate increases sharply before an earthquake. In Japan, on average, there are crustal motion sensors at a distance of 25 km from each other. These are stainless steel columns with a height of 4.5 m with a satellite coordinate system receiver at the top. Every 30 seconds, the receiver determines the coordinates of the sensor location with an error of about 2 mm. Laser rangefinders are also used to monitor the movements of the earth's crust. InSAR radar satellites, working in pairs, receive maps of the movements of the Earth's surface over large areas. Similar equipment was delivered to the ISS on 16.07.2008 .

Any change in the stress-strain state of the earth's crust affects the electrical resistance of rocks, as well as changes in the magnetic field caused by magnetic minerals. Hence the existence of electromagnetic precursors. In the late 1960s of the twentieth century, Rector of the Tomsk Polytechnic Institute A. Vorobyov expressed the idea that there should be electromagnetic fields underground associated with processes in the bowels of the Earth. For example, a friction force occurs at the points of contact of the blocks, leading to electrification. If the neighboring blocks "stick together", then the friction stops and the electromagnetic fields disappear, but the mechanical stresses removed by the earthquake accumulate.

Statistics show that usually the complex of blocks is destroyed after 8-10 days. The "calm" effect is an earthquake signal. But to increase the accuracy of the forecast, information from the network of observation stations in this area is needed. In the course of experiments, scientists have found out two mechanisms of electrification, important in the deformation of the Earth's crust:

– when two dielectrics or semiconductors come into contact, charge carriers diffuse and a contact potential difference occurs. And in the presence of a liquid, double electrical layers are formed on the solid–liquid interface. When these contacts break, various electrical effects occur;

– inside ion dielectrics (such is the substance of the earth's crust), when destroyed, charges move (the movement of charged dislocations and cracks) under the action of mechanical forces, which is equivalent to local currents. This is called mechanoelectric processes (MEP).

Observations are being made of changes in atmospheric electric potential, electrotelluric (Earth and ionosphere are the plates of a spherical capacitor) and geomagnetic fields, natural pulsed electromagnetic field. It was found that after the end of the disturbance of natural electromagnetic fields and ionospheric parameters (or at the final stage), seismic events can occur. But there is no complete correlation, because the reasons may be different. For example, the parameters of the ionosphere strongly depend on the cosmic impact and the geomagnetic situation. The electrical potential is affected by weather conditions. When forecasting, it is necessary to take into account the location of sources of disturbances in space.

MEPs occur during deformation and destruction of the Earth's crust in the following areas: the earthquake focus; the boundary of blocks and faults; the surface layer of the earth's crust experiencing deformation at the stage of earthquake preparation. (Subsurface layers, due to their high electrical conductivity, do not cause distortion of natural electromagnetic fields.) Thus, MEPs become sources of radiation in the radio range. They affect the electrotelluric and geomagnetic fields, as well as the atmospheric electrical potential. But the most effective will be a large-scale current source (tens of kilometers in size) obtained along the boundaries of the blocks, where many MEPs will run synchronously. Such a pulsating source operates at a frequency of 10-1000 Hz and is able to penetrate high into the ionosphere.

There is a hypothesis of Greek scientists (the group of P. Varotsos) about the piezocrystalline effect in some rocks that occurs before an earthquake.

Ionospheric. For the first time, instrumental observations of electromagnetic phenomena related to the preparation of an earthquake were performed in 1924 by B.A. Chernyavsky. He described the disturbance of atmospheric electricity before the Jalal-Abad earthquake in Uzbekistan. Before earthquakes of magnitude greater than 5, changes in the intensity of the vertical electrostatic field on the Earth's surface in the epicentral region from several tens to 1000 V/m were sometimes recorded a few hours before the shock.

Near the earth's surface, the field is vertical, and at ionospheric heights it unfolds parallel to the earth. A zone with a radius of tens to hundreds of kilometers is formed. In the ionosphere at an altitude of 100-120 km before an earthquake, the glow of atmospheric gas can be observed. Thus, the earthquake source inductively affects the lower part of the ionosphere. As a result of research, it was found that before a strong earthquake, the width of the earth–ionosphere waveguide changes: its upper wall (ion sphere) is lowered.

Initial information that the electromagnetic field in the waveguide either increases or weakens was obtained when lightning discharges with a regular daily course were registered. That is, an area with an increased or decreased concentration of charged particles is formed a few hours before the earthquake. The control of the lower part of the ionosphere, which is the wall of the waveguide, was carried out by oblique sounding of waves with a frequency of 10-15 kHz. The disturbed region of the ionosphere disrupted the normal propagation of radio waves, Fig. 5. Thus, the distortion of the phase of the radio signal was recorded before the earthquake in Uzbekistan on 09.10.1984.

G.T. Nestorov in Bulgaria on 4.03.1977, 1.5 hours before the earthquake in Romania (M = 7.2), detected feedings – rapid fluctuations and even fading of the radio signal (Fig. 5).

Calculations of short–term seismic hazard by taking into account the variability of the parameters of the earth-ionosphere waveguide showed that in one case out of five the forecast was false, strong omissions there were no earthquakes. In general, there have always been reports of noise in telephones, as in a thunderstorm, the smell of ozone during an earthquake and cases of electricity exposure to humans and animals.

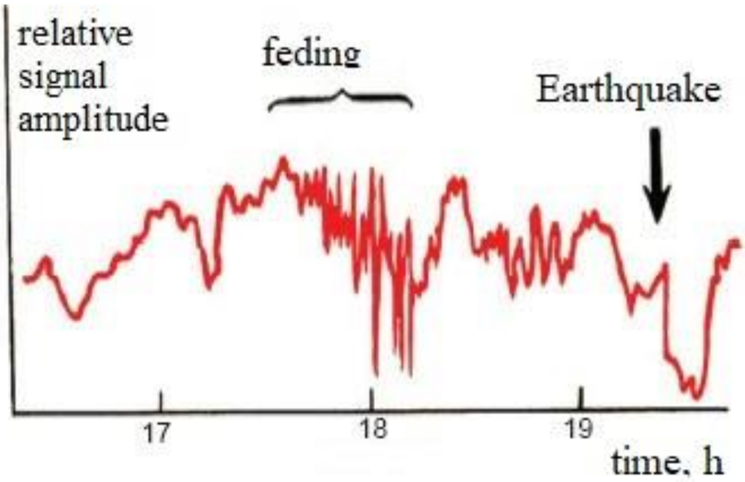

Figure 5 Radio signal phase disturbances 1.5 hours before the earthquake in Romania (M = 7.2)

Before an earthquake, mechanical and electrical stresses appear in the earth's crust.

The region of additional ionization can create secondary broadband radio emission and light effects, as well as distort the propagation of radio waves in the ultra-long-wave and long-wave bands.

A source pulsating on earth can cause a resonance of the Earth–ionosphere oscillatory circuit (v = ~ 102 Hz). This will cause a surge of alternating electric current in the ionosphere, its additional heating and ionization. As a result, new sources of radio waves may appear.

A more reliable sign of a strong earthquake is not a disturbance in the lower ionosphere, but an increase in the frequency of these disturbances.

The region of ionospheric disturbances can shift by 500-1000 km, i.e. the medium "chooses" the weakest place for a strong earthquake.

To increase the reliability of the forecast, it is necessary to take into account the energy saturation of the mountain environment (potential energy due to elastic deformations). In addition, some of its effects may be at higher levels of the same ionosphere.

As a result, scientists have proposed models linking the development of anomalies in the ionosphere with radon emissions, changes in the electric field strength in the atmosphere, perturbation of the ionosphere by low-frequency elastic vibrations that occur during the preparation of an earthquake. However, the listed changes are too small and not noticeable against the background of "noise". Unfortunately, they are detected only statistically, because they represent changes in the average characteristics of the ionosphere over certain periods of time during the preparation of an earthquake or during it.

Animal sensitivity (electromagnetic precursors, infrasounds). The nervous system has the greatest sensitivity in living organisms. Its electromagnetic properties are essential for the movement of blood. Charges (electrons, ions) that determine the processes of cell activity are continuously moving in an orderly manner in the body. In addition, there are bodies that specifically perceive the geomagnetic map of the area, which is necessary for orientation. All this combined makes it possible to feel the changes of electromagnetic and geomagnetic fields in the environment.

Scientists have found that the mechanism of orientation of birds and some animals is based on a delicate balance of complex chemical reactions, the course of which changes under the influence of a magnetic field, although it is very weak, about 50 mkTl. In general, it remains unclear what exactly affects animals, because animals on land (dogs, horses, elephants, etc.) and fish (in the sea and in aquariums – Japanese dwarf catfish, etc.) anticipate danger. Catfish are reliable indicators of tsunamis resulting from underwater earthquakes. In these fish (as well as in cyprinids, Barents Sea rays, trout, long-toed crayfish), a maximum of electrosensitivity in the range of 7-8 Hz was detected.

Hydrodynamic. Compression of rocks increases the level of groundwater and, consequently, the water level in wells and wells. The period of geysers may change.

Geochemical. The radon level changes. 15-20 hours before the mining impact (in mines) in the compression zone, the level of this gas decreases. But it increases 8-9 times in the far zone, where stretching occurs. A mountain shock occurs after passing the maximum concentration of radon. As a rule, the concentrations of radon dissolved in the groundwater of spilling wells are studied. The changes are felt 3-4 months before the seismic event and are especially clearly manifested in 1-2 weeks.

The permeability of the rock mass, the presence of associated pores and cracks in it significantly depends on its stress-strain state. Dynamic changes in radon concentration in the near-surface soil layer reflect this state.

Radon is radioactive and is a product of the alpha decay of radium. These chemical elements are part of the radioactive family of uranium-238. Radon is the optimal indicator for various geological studies. Its concentration in a mountain range is usually constant, because although some of the atoms enter the air, and some decay with a half-life of 3,825 days, this decrease is constantly compensated by a new intake, which depends on the concentration of uranium and, accordingly, radium in this mountain range. Gas jets, including radon, can come out from depths up to 200 m.

There are no problems with radon registration due to its radioactivity – it is reliably recorded even in small doses (30-50 decays in 1 m^3 per 1 s, i.e. 30-50 Bq/m^3, which corresponds to a concentration of 10-16% in a gas mixture). To implement the forecast, it is necessary to create a monitoring system for the entire seismogenic area. At the same time, the distance between the stations should not be more than 25 km, and data accumulation should be carried out for no more than 24 hours. In addition, charged particles emitted by radioactive radon ionize air molecules, generating condensation centers, and contribute to the formation of fog.

Sometimes zones of active geological faults manifest themselves by linear cloud clusters when observed from an airplane or from space. However, so far the forecast on cloud maps has not brought success.

The diffusion of light gases from the bowels of the Earth and the state of the structures formed in this case make it possible to predict the possibility of a strong earthquake with an accuracy of up to one day, but over a vast territory.

The influence of the relative position of the Moon and the Sun, because tides occur in the Earth's crust.

Questions for self-control

1) List the precursors of earthquakes
2) Earthquake prediction methods

HOW TO PREPARE FOR AN EARTHQUAKE

Think in advance of an action plan during an earthquake when you are at home, at work, in the cinema, theater, on transport and on the street. Explain to your family members what they should do during an earthquake and teach them the rules of first aid.

Keep documents, money, a pocket flashlight and spare batteries in a convenient place.

Have a supply of drinking water and canned food at home for several days.

Remove the beds from the windows and exterior walls. Secure cabinets, shelves and racks in apartments, and remove heavy objects from the upper shelves and mezzanines.

Store dangerous substances (toxic chemicals, flammable liquids) in a safe, well-insulated place.

All residents should know where the switch, main gas and water taps are located in order to turn off electricity, gas and water if necessary.

HOW TO ACT DURING AN EARTHQUAKE

Having felt the vibrations of the building, having seen the swinging of lamps, falling objects, having heard the increasing hum and the ringing of breaking glass, do not panic (from the moment when you felt the first tremors to the vibrations dangerous for the building, you have 15-20 seconds). Quickly exit the building, taking documents, money and basic necessities. When leaving the room, go down the stairs, not by elevator. Once on the street, stay there, but do not stand near buildings, but go to an open space.

Stay calm and try to calm others down! If you are forced to stay indoors, then stand in a safe place: at the inner wall, in a corner, in an inner wall opening or at a load-bearing support. If possible, hide under the table – it will protect you from falling objects and debris. Stay away from windows and heavy furniture. If you have children with you, cover them with yourself.

Do not use candles, matches, lighters – if gas leaks, a fire is possible. Stay away from overhanging balconies, cornices, parapets, beware of broken wires. If you are in a car, stay in the open, but do not leave the car until the tremors stop. Be ready to help rescue other people.

HOW TO ACT AFTER AN EARTHQUAKE

Provide first aid to those in need.

Free those trapped in easily removable rubble.

Be careful! Ensure the safety of children, the sick, the elderly. Calm them down. Do not use the phone unless absolutely necessary. Turn on the radio broadcast. Obey the instructions of the local authorities, the headquarters for the elimination of the consequences of a natural disaster.

Check if there is any damage to the electrical wiring. Fix the problem or turn off the electricity in the apartment. Remember that in case of a strong earthquake, the electricity in the city turns off automatically.

Check if there is any damage to the gas and water supply networks. Fix the problem or disconnect the networks. Do not use an open fire. Going down the stairs, be careful, make sure of its strength.

Do not approach obviously damaged buildings, do not enter them. Be prepared for strong aftershocks, as the first 2-3 hours after an earthquake are the most dangerous. Do not enter buildings unless absolutely necessary. Do not invent and do not pass on any rumors about possible aftershocks. Use official information. If you find yourself in a blockage, calmly assess the situation, if possible, provide yourself with medical assistance. Try to establish a connection with people outside the blockage (voice, knock). Remember that you can't light a fire, you can drink water from the toilet tank, and pipes and batteries can be used to signal. Save your energy. A person can go without food for more than half a month.

10 FOREST FIRE FORECASTING

Prediction of wildfires - determination of the probability of occurrence and dynamics of the development of wildfires with an assessment of the likely adverse consequences.

Forecasting can be of a long-term, short-term or operational nature.

The existing methods of assessing the forest fire situation allow us to determine the area and perimeter of the zone of possible fires in the region (region, district). The data for forecasting are the value of the forest fire coefficient and the time of fire development. The value of the forest fire coefficient depends on the natural and weather conditions of the region and the time of year. The time of development of fires is determined by the time of arrival of forces and means of fire elimination in the forest fire zone.

The solution of the forest fire problem is connected with the solution of a number of organizational and technical problems and, first of all, with the conduct of fire-fighting and preventive work carried out as planned and aimed at preventing the occurrence, spread and development of forest fires.

Measures to prevent the spread of forest fires provide for the implementation of a number of forestry measures (sanitary logging, clearing of logging sites, etc.), as well as special measures to create a system of fire barriers in the forest and the construction of various fire-fighting facilities.

It must be remembered that the forest becomes unburnable if it is cleared of dryness and dead wood, the undergrowth is eliminated, 2-3 mineralized strips are laid with a distance between them of 50-60 m, and the over-ground cover between them is periodically burned.

The initial data for predicting the appearance of a source of damaging factors — the occurrence of a forest fire are:

- fire hazard class in the forest according to weather conditions;
- location and area of forest fund plots of fire hazard classes I—III and/or plots of different fire hazard classes, where at the time under consideration LGM can burn when a fire source appears;
- terrain data (plain, plateau, plateau, highlands, mountains; hills, hills; hollows, ravines);
- the presence of potential sources of fire in the listed areas of the forest fund, where LGM can burn at the time under consideration when a fire source appears; data on thunderstorm activity;
- the results of a retrospective analysis of the distribution of fires over time (the number of fires by years, months, decades, days, hours of the day) and by territory (forest quarters, forestry, forestry, forestry departments of the subjects of the Russian Federation) of the considered area, region or comparable to them in terms of natural and economic conditions over the past 10 years.

The degree of fire danger in the forest according to weather conditions should be determined by V. G. Nesterov's complex indicator adopted in forestry, which is calculated based on data on air temperature, dew point temperature, and the amount of precipitation.

Fire hazard according to weather conditions determines the possibility of burning of forest combustible materials, depending on their humidity, determined by weather conditions.

The fire hazard indicator (fire hazard class – KPO) in the forest according to weather conditions is determined at 12...14 hours local time as the sum of the product of the air temperature (t°) by the difference in air temperature and the point

$KPO=\sum[t^{\circ}(t^{\circ}-\eta)]$

dew (η) for (n) days without rain.

The all-Russian scale has five classes of fire danger in the forest according to weather conditions (Table 4).

In many regions, in accordance with the methodology for compiling KPO scales, local fire danger scales have been developed and applied, taking into account the seasonality of the burnability and its dependence on the value of the complex indicator, i.e. there are other values of complex indicators that determine the boundaries of KPO and they differ from the values of the all-Russian scale.

Table 4— Scale of fire danger in the forest by weather conditions

Fire hazard class according to weather conditions	The value of complex indicator	Degree of fire dangers
I	Before 300	—
II	301- 1000	Small
III	1001- 4000	Average
IV	4001 - 10000	High
V	More 10000	Emergency

With class I fire hazard, most of the causes (sources of fire) do not cause fires, although fires from sources of high temperatures and lightning are possible (with dry thunderstorms). Fires that have arisen and are active spread slowly, unevenly or cease to operate.

At the II class of fire danger, fires can occur from strong sources of fire, but the number of fires is small. The speed of fire propagation is negligible.

At the III class of fire danger, most fire sources lead to forest fires. Fires are intense, emit a large amount of heat, spread quickly and create additional small foci.

At the IV class of fire danger, fires arise even from insignificant sources of fire, spread quickly and create additional small foci.

At the V class of fire danger, fires arise from any source of fire and high temperatures. Gorenje occurs very intensively and the fire spreads quickly.

The relative assessment of the degree of fire danger of forest areas according to the conditions of occurrence of forest fires in them and their possible intensity on a five-point scale is given on forest fire maps and fire-prevention measures on a scale of 1:100000, on which each forest quarter is colored with the color of the average fire hazard class (Table 5). On forest fire maps of scale 1:50000 and 1:25000, the color of a specific fire hazard class is painted over the allotments that make up the forest quarters.

Table 5— Fire hazard classes of forest areas and paint colors

Fire hazard class of forest areas	Degree of fire danger	The color of the paint on the maps
I	High	Red
II	Above average	Orange
III	Average	Yellow
IV	Below average	Green
V	Low	Blue

Forecasts of the distribution of forest fires across the territory are given by:

- forestry;
- forestry enterprises;
- the forestry management body of the subject of the Russian Federation.

Forecasts of the distribution of fires over time include:

- distribution of fires by time of day;
- the distribution of fires by months of the fire season with the allocation of periods of fire peaks and peaks and the calculation of the likely number of fires in these periods;
- distribution of fires by decades of the fire season;
- number of fires in 1 day (average, minimum, maximum);
- number of forest fires per year (fire season);
- the beginning and duration of fire-hazardous seasons.

All other things being equal, a forest fire occurs earlier in sections of fire hazard class I and last of all in sections of fire hazard class V.

The number of forest fires is predicted based on:

- fire hazard class in the forest according to weather conditions;
- fire hazard class of forest areas in the territory under consideration;
- the number of potential sources of fire;
- the number of fires in retrospect in similar conditions;
- theoretical laws of distribution of random events, which satisfactorily describe (approximate) some series of distribution of forest fires in time and territory.

Types of forest fires with this complex indicator of fire danger in the forest, according to weather conditions and specific wind strength, are predicted based on the nature of the forest fund sites (coniferous young trees, cluttered logging, pine-birch plantations on blocked soils, middle-aged pine plantations on a mountain slope, Mongolian oak plantations, other types of forest fund sites).

The forecast of the probable rates of spread of forest fires of different types at different classes of fire danger in the forest according to weather conditions is made for different types of forests and forest areas, that is, taking into account the prevailing types of LGM or their complexes and their reserves, as well as the terrain and wind strength.

The prerequisites for an emergency forest fire situation are:

- a low-snow winter, a long rainless period (15-20 days) with a high (above the average long-term) average daily air temperature and low relative humidity at the beginning of the fire season, when the degree of fire danger in the forest is characterized by IV, V classes of fire danger according to weather conditions; a long period with IV, V fire hazard classes, atmospheric drought at any time of the fire season;
- the presence of uncontrolled anthropogenic sources of fire in the forest fund and/or frequent lightning discharges with a high degree of fire danger in the forest according to weather conditions.

Example

Initial and calculated data on a large fire in the area of Verkhnyaya Pyshma in 2017.

Date	Precipitation amount	T_0	T_0 - τ	KP	Fire hazard class
25.04	Daily precipitation at 9 o'clock local time in the amount of 13 mm	+12,5	+11,6	145	I class
26.04	There was no precipitation	+10,4	+13,8	288,52	I class
27.04	There was no precipitation	+13,6	+14,7	488,44	II class
28.04	There was no precipitation	+19,7	+20,8	898,20	II class
29.04	There was no precipitation	+12,7	+19,1	1140,77	III class
30.04	There was no precipitation	+12,8	+25,2	1463,33	III class
01.05	There was no precipitation	+17,2	+24,9	1891,61	III class
02.05	There was no precipitation	+25,1	+26,3	2551,74	III class
03.05	There was no precipitation	+22,5	+21,1	3026,49	III class
04.05	Daily precipitation at 9 o'clock local time in the amount of 2.9 mm	+11,7	+15,3	3205,50	III class
05.05	Daily precipitation at 9 o'clock local time in the amount of 0.9	+5,5	+11,9	3270,95	III class
06.05	Daily precipitation at 9 o'clock local time in the amount of 0.9	+7,2	+12,6	3361,67	III class
07.05	Daily precipitation at 9 o'clock local time in the amount of 1.2	+3,0	+2,5	3369,17	III class
08.05	Daily precipitation at 9 o'clock local time in the amount of 5.9	+6,8	+15,4		

25.04 KP = 12,5x11,6 = 145 I class
26.04 KP = 145+(10,4x13,8) = 288,52 I class
27.04 KP = 288,52+(13,6x14,7) = 488,44 I class
28.04 KP = 488,44 +(19,7x20,8) = 898,20 I class
29.04 KP = 898,20 +(12,7x19,1) = 1140,77 II class
30.04 KP = 1140,77 +(12,8x25,2) = 1463,33 II class
01.05 KP = 1463,33+(17,2x24,9) = 1891,61 III class

02.05 KP = 1891,61+(25,1x26,3) = 2551,74 III class
03.05 KP = 2551,74+(22,5x21,1) = 3026,49 III class
04.05 KP = 3026.49+(11,7x15,3) = 3205,50 III class
05.05 KP = 3205,50+(5,5x11,9) = 3270,95 III class
06.05 KP = 3270,95+(7,2x12,6) = 3361,67 III class
07.05 KP = 3361,67+(3,0x2,5) = 3369,17 III class

The Nesterov index is the most common of the existing indicators of fire burnability. But the fire danger in the forest is caused not only by the level of drought. It also depends on the number of fire sources in the protected area, the nature of vegetation and its phenological state. Therefore, with the same indicator, there may be a different level of fire danger not only in different areas, but also in the same area, but in different periods of the season.

Questions for self-control

1) Methods of forecasting forest fires.
2) What is the Nesterov indicator.

What should I do if I find myself in a forest fire zone?

If the fire is grassroots or local, you can try to extinguish the flame yourself - to knock it down, overflowing with branches of hardwoods, pouring water, throwing wet soil trampling with your feet. When extinguishing a fire, act carefully, do not go far from roads and glades, do not lose sight of other participants, maintain visual and audio communication with them.

If you are unable to cope with the localization and extinguishing of the fire on your own:

• immediately warn everyone in the vicinity of the need to leave the danger zone;
• organize the exit of people to the road or clearing, a wide clearing, to the bank of a river or reservoir, in the field;
• exit the danger zone quickly, perpendicular to the direction of movement of the fire;
• if it is impossible to escape from the fire, enter the pond or cover yourself with wet clothes;
• once in an open space or clearing, breathe while crouching down to the ground - the air is less smoky there;
• cover your mouth and nose with a cotton gauze bandage or cloth;
• after leaving the fire zone, report the location, size and nature to the fire service, the administration of the settlement, forestry.

If there is a possibility of a fire approaching your locality, prepare for a possible evacuation:

• put documents, valuables in a safe, accessible place;
• prepare vehicles for possible emergency departure;

• wear cotton or woolen clothing, have with you: gloves, a handkerchief with which you can cover your face, protective glasses or other eye protection;

• prepare a supply of food and drinking water;

• carefully monitor information messages on television and radio, means of notification, keep in touch with friends in other areas of your area;

• avoid panic.

If you find hotbeds of fire, you need to call the "Rescue Service" by phone "01" from the mobile "112".

CONCLUSION

The monitoring and forecasting of natural and man-made emergencies is very multifaceted due to their wide variety. It is carried out by many organizations (institutions), while using various methods and means. For example, monitoring and forecasting of hydrometeorological events is carried out by institutions and organizations of Roshydromet, which, in addition, organizes and monitors the state and pollution of the atmosphere, water and soil.

Seismic observations and earthquake prediction in the country are carried out by the federal system of seismological observations and earthquake prediction, which includes institutions and observation networks of the Russian Academy of Sciences, the Ministry of Emergency Situations of Russia, the Ministry of Defense of Russia, Gosstroy of Russia, etc.

An important role in the monitoring and forecasting of emergency situations is played by the Ministry of Natural Resources of the Russian Federation, which provides general management of the state environmental monitoring system, as well as coordination of activities in the field of monitoring the state of the environment.

Monitoring of the state of man—made facilities and the forecast of accidents are organized and carried out by federal supervisors - Gosgortehnadzor of Russia and Gosatomnadzor of Russia, as well as supervisory authorities within federal executive authorities. It should be noted that the supervisory authorities also have, as part of the executive authorities of the constituent entities of the Russian Federation, and at enterprises and organizations, divisions for industrial safety of enterprises and organizations.

There are other types of monitoring and forecasting carried out in departmental and other interests for different types of objects, phenomena and processes, controlled ingredients and parameters for various types of hazards.

It should be emphasized that the quality of monitoring and forecasting of emergency situations has a decisive impact on the effectiveness of activities in the field of reducing the risks of their occurrence and scale.

The emergency monitoring and forecasting system is a functional information and analytical subsystem of the Emergency Management System. It unites the efforts of the functional and territorial subsystems of the RSF in terms of monitoring and forecasting emergency situations and their socio-economic consequences.

The methodological basis for solving forecasting problems is the appropriate methods.

In general, the results of monitoring and forecasting are the initial basis for the development of long-term, medium-term and short-term targeted programs, plans, as well as for making appropriate decisions on the prevention and elimination of emergency situations.

Without taking into account the data of monitoring and forecasting of emergency situations, it is impossible to plan the development of territories, make decisions on the construction of industrial and social facilities, develop programs and plans for the prevention and elimination of possible emergencies.

The effectiveness and quality of monitoring and forecasting largely depends on the effectiveness and quality of programs, plans and decision-making for the prevention and elimination of emergency situations.

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Стр.