Lecture 1. The concept of emergency situations, their classification and brief characterisation. The system of defence against natural and man-made emergencies

Lecture outline:

1.1. Legislation of the Republic of Belarus in the field of protection from natural and man-made emergencies, civil defence. Classification of emergency situations.

1.2. The State System of Prevention and Elimination of Emergency Situations.

1.3. Civil Defence of the Republic of Belarus.

1.4. Notification of citizens about emergency situations. Procedure of actions of employees of organisations and population in emergency situations.

1.1 Legislation of the Republic of Belarus in the field of protection from natural and technogenic emergencies, civil defence. Classification of emergency situations

The main legislative documents in the field of protection of population and facilities from emergency situations and civil defence are:

1. Law of the Republic of Belarus "On Protection of Population and Territories from Natural and Technogenic Emergencies" No. 141-Z of 05.05.1998.

2. Law of the Republic of Belarus "On Civil Defence" No. 183-Z of 27.11.2006.

3. Resolution of the Council of Ministers of the Republic of Belarus "On the State System of Prevention and Elimination of Emergency Situations" No. 495 of 10.04.2001.

The Law of the Republic of Belarus "On Civil Defence" defines:

- organisation and maintenance of civil defence;
- the main tasks of the CS;
- the powers of the President of the Republыc of Belarus and the authorities in the field of civil defence;
- rights and duties of citizens in the field of civil defence;
- management of the civil defence of the Republic of Belarus;
- civil defence forces;
- GO funding.

Liability for violation of legislation. Code of the Republic of Belarus on Administrative Offences. Article 23.58. Violation of legislation in the field of protection of population and territories from emergency situations:

1. Violation of the legislation, which resulted in the creation of conditions for the emergence of an emergency, shall entail a warning or a fine of 20 to 50 basic units, and up to 200 basic units for a legal entity.

2. Failure by an official to take measures to protect life and health of people shall entail a fine in the amount of 50 to 100 basic units.

The concept and classification of emergency situations. An emergency situation is a situation that has developed on a certain territory as a result of an accident, catastrophe, natural disaster, which may entail human casualties, environmental damage and significant material losses.

In accordance with the Law of the Republic of Belarus "On Protection of Population and Territories from Natural and Technogenic Emergencies", emergencies are classified depending on the ***territorial spread, number of people affected, and amount of material damage*** (Table 1).

Table 1

Classification of emergencies

Emergencies depending on territorial distribution	**Number of people affected**	**Amount of material damage, base value**
Localised. The emergency zone does not extend beyond the territory of the facility	no more than 10 people.	over 40, but not more than 1 thou.
Local. The emergency zone does not go beyond the city, district boundaries	over 10, but not more than 50 people.	over 1 thousand, but not more than 5 thousand.
Regional. The emergency zone does not extend beyond the region's boundaries	over 50, but not more than 500 people.	over 5 thousand, but not more than 0.5 million.
Republican. The emergency zone extends beyond more than two oblasts	over 500 people.	over 0.5 million.
Transboundary. An emergency situation extends beyond the borders of the Republic of Belarus and affects its territory, if it occurs abroad	___	___

According to the sphere of occurrence, emergencies are divided into:

- natural, associated with the manifestation of natural forces of nature (earthquakes, volcanoes, tsunamis, storms, etc.);
- technogenic, related to technical objects (fire, explosions, collapse of buildings, release of radioactive substances, etc.);
- environmental, related to abnormal changes in the biosphere and natural environment (desertification, soil degradation, pollution, ozone layer destruction, etc.);
- biological, related to the spread of infectious diseases of people, animals and damage to agricultural plants (epidemics, epizootics, epiphytotics, etc.);

- social, related to social events (terrorism, violence, gang violence, drug addiction, alcoholism, wars, prostitution, etc.);
- anthropogenic, resulting from human error; combined, including several causes of emergencies.

1.2 The State System of Prevention and Elimination of Emergency Situations

The State System for Prevention and Elimination of Emergency Situations (SSES) is a system uniting republican bodies of state administration subordinate to the Council of Ministers of the Republic of Belarus, local executive and administrative bodies and other organisations.

Republican bodies of state administration and other state organisations subordinate to the Council of Ministers of the Republic of Belarus:

- Ministry of Emergency Management;
- Ministry of Health;
- Home Office;
- Ministry of Communications and Informatisation;
- Ministry of Foreign Affairs;
- Ministry of Agriculture and Food;
- Ministry of Transport and Communications;
- Ministry of Architecture and Construction;
- Ministry of Forestry;
- Ministry of Finance;
- Ministry of Defence;
- Ministry of Natural Resources and Environmental Protection;
- Ministry of Education;
- Ministry of Housing and Utilities;
- Ministry of Labour and Social Protection;
- Ministry of Trade, Belarusian Republican Union of Consumer Societies;
- Committee on Problems of the Consequences of the Chernobyl NPP Catastrophe under the Council of Ministers of the Republic of Belarus;
- State Security Committee;
- State Customs Committee;
- State Border Committee;
- State Committee on Science and Technology;
- State Committee for Standardisation;

Belarusian Republican Unitary Insurance Enterprise Belgosstrakh.

The main purpose of the State Emergency Situations Service is to plan, organise and execute measures to protect the population and territories from emergencies, as well as to prepare for civil defence activities.

The structure of the SES is based on two main principles: administrative-territorial and sectoral. In accordance with the above-mentioned principles, there are

four levels of the State Emergency Situations Service: *republican, territorial, local and facility.*

Emergency response forces include:

1. Emergency Management Units.
2. Health organisations and medical formations.
3. Emergency Services.
4. Civilian formations of civil defence.
5. Veterinary service organisations and plant protection stations.
6. Specialised divisions of the construction complex.

The following assets shall be used to respond to emergencies:

- communication and control facilities;
- rescue equipment;
- gear;
- equipment and tools;
- personal protective equipment;
- guidance materials;
- video, film, photo materials on the technology of rescue and other emergency operations, etc.

Monitoring and forecasting system is a set of systems for observation, analysis and assessment of emergency sources, forecasting of emergencies in order to take measures for prevention and elimination of natural and man-made emergencies.

Monitoring and forecasting of emergencies are carried out:

1. At the republican level - the Ministry of Emergency Situations.

2. At the territorial level - regional departments of the Ministry of Emergency Situations and Minsk City Department of the Ministry of Emergency Situations.

3. at the local level - city and district emergency departments of Minsk city and regional departments of the Ministry of Emergency Situations.

Monitoring and forecasting of emergencies is carried out by republican state administration bodies

In order to exchange information on emergency situations, the Monitoring and Forecasting System interacts with the National Environmental Monitoring System and the Social and Hygienic Monitoring System.

The information and management system of the SES includes:

1. Information centres of republican bodies of state administration, other state organisations.
2. Duty dispatch services of districts, cities and organisations.

3. State Institution "Republican Centre for Emergency Management and Response of the Ministry of Emergency Situations of the Republic of Belarus".

4. Operational control centres of Minsk city departments of the Ministry of Emergency Situations and regional departments of the Ministry of Emergency Situations.

5. Operational control centres of district and city emergency departments.

Material resource reserves are established at the following levels:

- Republican;

- sectoral and territorial;
- local and facility.

The main material resources intended for emergency response are:

- food and food raw materials;
- medical devices and medicines;
- building materials;
- personal protective equipment.

Depending on the situation and the scale of the emergency, the following **modes of functioning of the SES** are distinguished**:**

- day-to-day operations mode;
- on high alert;
- emergency regime.

The regime of daily activities is carried out under normal conditions (hydrometeorological, seismic, industrial, chemical, radiation, biological) in a certain territory.

The regime of increased readiness is introduced in case of deterioration of the situation (hydrometeorological, seismic, industrial, chemical, radiation, biological) and when a forecast of an emergency situation is received.

The introduction of emergency regime is associated with the emergence and liquidation of emergency situations.

The main activities carried out during the functioning of the SES regimes are:

in day-to-day operations:

- monitoring and forecasting of emergency situations;
- planning and implementation of programmes of a targeted and scientific and technical nature;
- carrying out measures to protect the population and ensure sustainable functioning of economic facilities in emergencies, as well as measures to prevent emergencies;
- training of managers and employees of the State Emergency Situations Service to act in emergencies, training of the population to act in emergencies;
- Establishment of reserves of material resources intended for the elimination of emergency situations;
- insurance of employees and citizens in emergencies;

on high alert:

- setting up task forces to find out the reasons for the deterioration of the situation in a certain territory and to develop proposals to normalise the situation;
- refinement of plans for protection of the population from emergency situations, as well as plans for prevention and elimination of emergency situations of organisations;
- strengthening of individual elements of the information and control system (duty and dispatch services);
- monitoring and forecasting of natural and man-made emergencies;

- carrying out priority measures to provide life support to the population, increase the sustainable functioning of economic facilities and protect the environment;
- Putting the forces and means of the State Emergency Situations Service on standby and moving them, if necessary, to the emergency area.

in emergency mode:

- introduction of plans for protection of population and territories from natural and man-made emergencies, as well as plans of organisations aimed at prevention and elimination of emergencies;
- advancement of operational teams to the emergency zone;
- emergency response;
- defining the boundaries of the emergency zone;
- organisation of works on life support of the population affected by emergencies, as well as works on ensuring sustainable functioning of economic facilities in emergencies;
- Continuous monitoring and forecasting of the emergency.

1.3 Civil defence of the Republic of Belarus

Civil defence is an integral part of the defence measures of the Republic of Belarus to protect the population and material values from dangers arising in the course of military operations.

Civil defence is organised according to administrative-territorial and sectoral principles.

The conduct of civil defence is determined by ***civil defence*** plans, which are put into effect in the territory of the Republic of Belarus from the moment war is declared, hostilities actually begin or martial law is declared by the President of the Republic of Belarus.

The main tasks of civil defence (CD):

- training of the population in methods of defence against wartime hazards;
- ensuring sustainable functioning of economic facilities and life support systems (water, food, medical support) of the population in wartime;
- alerting the population to the dangers associated with military operations;
- temporary resettlement of the population, provision of personal and collective protection equipment;
- evacuation of material assets to safe areas in case of threat of their theft or destruction;
- carrying out emergency rescue and other urgent works (AS and DNR);
- Sanitary treatment of the population exposed to radioactive, chemical and biological contamination;
- Maintaining public order in areas affected by wartime hazards.

Elements of the organisational structure of civil defence:

- Management of civil defence in the Republic of Belarus;
- Civil defence management bodies;
- Civil defence forces

Civil defence management is carried out not only in wartime, but also in peacetime. *In wartime, civil defence management is carried out by the CS headquarters.*

Civil defence forces include: civil defence services, civilian civil defence formations, civil defence observation and laboratory control network.

Civil Defence Services. Depending on the administrative-territorial principle of civil defence organisation and the functions performed, the following civil defence services are distinguished:

- Republican;
- regional;
- neighbourhoods;
- urban;
- Organisations' services.

Civil defence services are assigned the following main tasks:

- ***the medical service*** - control over the sanitary and epidemic situation, as well as sanitary-hygienic, anti-epidemic and therapeutic-evacuation measures;
- ***the fire rescue service*** - organisation and performance of rescue and other emergency works, measures to localise and extinguish fires;
- ***engineering and technical service*** - restoration and repair of buildings, organisation of construction of fast-erecting shelters and restoration of destroyed protective structures;
- ***on the communal and technical service*** - control over the condition of networks and facilities of the communal ***services***, organisation of emergency recovery works on the above mentioned networks and facilities;
- ***the fuel and lubricants service*** - providing vehicles of civilian civil defence formations with fuel and lubricants (petrol, motor oil, brake fluid, etc.);
- ***public order protection service*** - ensuring public order in emergency zones (ensuring the order of entry and exit of citizens and vehicles, combating crime, etc.), protection of economic facilities (transport, communications, electricity, etc.), material and historical and cultural values;
- ***on the service of protection of agricultural animals and plants*** - organisation and implementation of measures for protection of agricultural animals and plants, as well as livestock and crop production from emergency situations;
- ***information transmission and dissemination service*** - organisation of information transmission and communication to the population about emergencies, rules of conduct when receiving civil defence signals;
- ***communication service*** - providing civil defence authorities with communication channels, operational and technical maintenance of warning systems to communicate information on emergency situations to the population;

- ***the trade and catering service*** - provision of food, clothing and footwear to civilian civil defence formations, as well as to the affected population in emergency zones;
- ***The transport support service is responsible for*** organising and carrying out evacuation of the population, material and historical and cultural values to safe areas, as well as civilian civil defence formations to areas of destination;
- ***energy supply service*** - ensuring sustainable functioning of energy networks, elimination of accidents on the above mentioned networks, organisation of purchase of reserve sources of energy supply in the organisations of the Ministry of Energy.

Civilian civil defence formations are designed to carry out rescue and other emergency work in emergencies, both peacetime and wartime. CDFGs are established in organisations that have hazardous facilities or facilities of important economic and defence significance.

Object civilian formations are created by the heads of civil defence of organisations. The main purpose of the above-mentioned formations is to carry out emergency rescue and other urgent work in the respective organisations during emergencies.

Civilian general purpose formations are intended to carry out AS and DNR of a general nature. These activities include:

- clearing and opening rubble, damaged shelters and refuges;
- Searching for and extracting people from collapsed structures;
- providing first aid to victims and organising the transportation of victims to medical institutions.

The constituent elements of general purpose civilian formations are: combined squads, teams and groups.

Civilian special-purpose formations shall carry out:

- liaising and conducting reconnaissance;
- providing medical care;
- localising and extinguishing fires;
- community policing;
- carrying out and logistical support of measures to ensure the safety of the population (anti-radiation, anti-chemical, sanitary-hygienic and anti-epidemic).

Special-purpose civilian formations are also intended to support the activities of general-purpose civilian formations.

Depending on the nature of the tasks performed in various emergencies, the following civilian civil defence formations are distinguished:

- forming a bond;
- firefighting;
- medical;
- of the intelligence formation;
- radiation, chemical and biological defence;
- automotive;
- emergency and engineering;

- formations of mechanisation of work;
- trade and catering;
- community policing.

In wartime, the total number of the civilian formation of the Civil Defence Forces must be at least 20% of the organisation's full-time employees.

1.4 Notification of citizens about emergency situations. Procedure of actions of employees of organisations and population in emergencies

Emergency notification is the delivery of notification signals and information about the threat of natural and man-made emergencies, rules of behaviour, and the course of liquidation of the consequences of the emergency to the population and the emergency management bodies of the State Emergency Service.

In the Republic of Belarus, **an automated centralised warning system (ACWS)** is used to notify the population of emergency situations.

Notification system is an organisational and technical integration of forces, means of notification and information, means of telecommunication and mass information, which provide notification and information to the population and the emergency management bodies of the State Emergency Situations Service.

Levels of operation of the warning system:

- republican (territory of the Republic of Belarus);
- territorial (territory of the region and the city of Minsk);
- local (territory of the district and city);
- object (territory of the object or areas of possible threat from this object).

Technical means of the ASCS:

1. electric horns and signalling loudspeaker installations.
2. Street loudspeakers.
3. telephone and cellular communication (sending SMS messages).
4. television.
5. Wireless radio broadcasting (interception of FM channels).
6. Internet Network.

There are 4,500 electric horns and 1,500 street loudspeakers in use in the Republic of Belarus.

The main method of notification of the population about emergencies in the Republic of Belarus is the transmission of speech information. Transmission of this type of information to the population may be carried out with interruption of TV and radio broadcasting programmes for no more than 5 minutes. In addition, two or three times repetition of speech information transmission is allowed.

In the territories not covered by ASCCs (gardening communities, sparsely populated areas), vehicles with loudspeaker signalling systems can be used to alert the population. There are more than 5.3 thousand vehicles equipped with these devices in Belarus.

In peacetime, one civil defence signal with the conventional name ***"Attention All!"*** is used**.**

This signal is transmitted to the population by switching on sirens or other signalling devices for 3 minutes. Upon hearing the signal ***"Attention All!"***, every citizen should switch on a radio, radio receiver, TV set to a local station. The above-mentioned means of notification will transmit information about the emergency situation and instructions for protection.

In wartime, in addition to the ***"Attention All!"*** signal, other civil defence signals are also used: ***"Air Alert!", "Cancel Air Alert!", "Chemical Alert!", "Radiation Danger!".*** When an air, chemical or radiation danger occurs, the signal "Attention All!" is transmitted first, followed by information. For example, "Attention! Attention! Citizens! Radiation danger!" etc. After the transmission of GO signals, recommendations for protection will be given.

Procedure for actions of employees of organisations and population in natural and man-made emergencies:

1. Understand from the transmitted information the location of the emergency, the direction of spread of the striking factor (in case of flooding - the path of water spread; in case of an accident at a chemical plant - the direction of movement of the poisonous cloud), ways and means of evacuation.

2. In case of an accident at a chemically hazardous facility - prepare personal respiratory and skin protection equipment.

3. set up a shelter in your home or prepare essentials for evacuation (first aid kit, food and drinking water, personal documents, warm clothes).

Rules of behaviour in the event of war-related hazards:

1. If an alert signal is received at home:

- cut off the gas and electricity;
- prepare documents, money, food and medical supplies for evacuation;
- to leave the building and go down to the nearest shelter.

2. If the notification signal is caught on the street or in public transport:

- we need to find the nearest shelter;
- If the latter is not available, basements, underground passages, metro stations can be used. You can also take shelter in all sorts of ditches, ravines, etc.

3. If the alert signal is caught in a shop, market or theatre:

- you must listen carefully to the administration's instructions about where the nearest shelter is;
- If there are no instructions from the administration, you should: go outside, look around and locate the nearest shelter.

Procedures for dealing with acts of terrorism*:*

- do not touch ownerless packages (bags, boxes, etc.) found in the entrance of the house, on the street or in public transport;
- If there is an explosion, prevent the fire from spreading, take measures to prevent panic and provide first aid to the injured;
- To minimise blood loss in case of injury, move as little as possible;

- In the presence of terrorists, it is necessary to remain calm, refrain from sudden movements and shouting;
- If there is a threat of terrorists using weapons, lie on your stomach, cover your head with your hands, and stay away from windows and glass doors;
- every opportunity for rescue must be seized.

Control questions

1. Name the main legislative documents in the field of protection of population and objects from emergency situations and civil defence.
2. Formulate the definition of "Emergency".
3. Specify the types of emergencies depending on the territorial spread, number of people affected, volumes of material damage.
4. What is the structure of the state system of prevention and elimination of emergency situations?
5. List the republican bodies of state administration and other state organisations that are part of the state system of prevention and elimination of emergency situations.
6. Name the levels of the state system of prevention and elimination of emergency situations depending on the administrative-territorial and sectoral principles of construction.
7. Formulate the definition of the concept of "Civil Defence". Name the elements of the organisational structure of civil defence.
8. List the technical means of the automated centralised warning system.
9. Specify peacetime and wartime civil defence signals.
10. Characterise the procedure of actions of the population in case of terrorist acts.

Lecture 2. Training of the population in the field of defence from natural and man-made emergencies

Lecture outline:

2.1 Rights and duties of citizens in the field of protection from emergency situations. Training of personnel of organisations in the field of protection from natural and man-made emergencies and civil defence.

2.2 Classification and brief characterisation of natural emergencies. Recommendations on actions of citizens in case of threat and occurrence of natural emergencies.

2.3 Natural emergencies specific to the Republic of Belarus.

2.1 Rights and obligations of citizens in the field of emergency protection. Training of personnel of organisations in the field of protection from natural and man-made emergencies, civil defence

Citizens of the Republic of Belarus have the right in the field of protection from emergency situations to:

1. Information on risks and safety measures.
2. Use of personal and collective protective equipment.
3. Protection of health, life and property.
4. Compensation for damage from emergency situations.
5. Free state insurance for damage caused during emergency response.
6. Pension provision in case of disability due to fulfilment of public protection duties.
7. Pension for the loss of a breadwinner who died in the performance of such duties.
8. Free medical care in the emergency zone.
9. Addressing individual and collective enquiries to the management bodies on protection issues.

The responsibilities of citizens include:

1. Compliance with legal and regulatory acts in the field of emergency protection.
2. Observing safety measures in everyday life and at work.
3. learning first aid and the use of protective equipment.
4. Compliance with the rules of behaviour in emergencies.

Training of employees of the State Emergency Service is carried out at their place of work, in educational institutions, on courses and in training and methodological centres.

2.2 Classification and brief characterisation of natural emergencies natural emergencies. Recommendations on actions of citizens in case of threat and occurrence of natural emergencies

A natural emergency is a situation in a certain territory caused by natural factors, which may lead to human casualties, material losses and damage to the environment.

Natural emergencies are divided into groups **depending on the sphere of occurrence**: natural hazards, fires in ecosystems and biological and social emergencies (fig. 1).

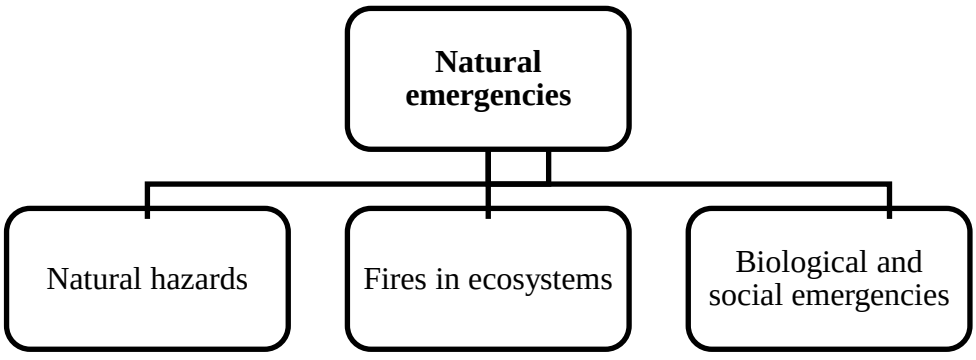


Fig. 1. Natural emergencies by sphere of occurrence

The sources of a natural emergency include natural hazards, which are events of natural origin that are capable of causing damage to people, the economy and the environment in terms of their duration and magnitude (fig. 2).

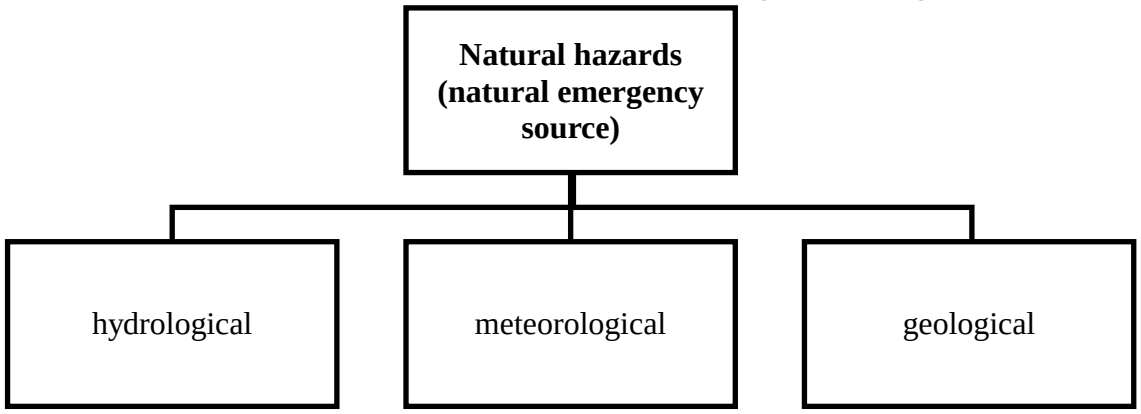


Fig. 2. Natural hazards

Hydrological (or water) hazards include:

- **Waterlogging** is an increase in the groundwater level that disrupts the construction and operation of facilities.
- **Flooding** - inundation of an area with water.
- **Flood** is a prolonged rise in the water level of a river caused by snowmelt.
- **High water period** is a short-term rise in water level caused by rainfall or snowmelt.
- **Ice jam** - accumulation of ice in the river channel during ice drift and the associated rise in water level.
- **Zajor** - accumulation of in-water ice under surface ice and the associated rise in water level.
- **Wind surge** is an increase in water level due to high winds.
- **Mudslide** is a rapid flow of water and debris resulting from intense rainfall.
- **Snow avalanche** is a sudden movement of snow down steep mountain slopes.
- **Tsunamis** are super-powerful sea waves generated by underwater earthquakes.

Hazardous meteorological phenomena include two main groups - aerodynamic and agrometeorological.

Aerodynamic phenomena are related to the movement of air masses and are subdivided into horizontal and vertical directions.

Horizontal air movement manifests itself as wind. Vertical motion can create thermal flows, cyclones, anticyclones, and other atmospheric phenomena.

Wind speed is measured using the Beaufort scale developed by Irish Admiral Francis Beaufort in 1805. After refinements, the scale was adopted by the World Meteorological Organisation in 1963.

Aerodynamic hazards include:

Storm - strong wind (more than 20 m/s) causing significant destruction on land and unrest at sea. The main variety is whirlwind storms, which can spread over large areas.

- *Squall* - a sharp short-term increase in wind, up to 50 kilometres wide and 700 kilometres long. It may be accompanied by showers, thunderstorms and dust storms, lasting from a few minutes to 1.5 hours.
- *Snowstorm* is a winter wind with a speed of more than 15 m/s at a temperature of about -7 °C, accompanied by snowfall. The duration can be from a few hours to several days.
- *Dust (sand) storm* - wind of more than 10 m/s, moving large amounts of sand and dust to distances of up to 500 km. Duration from several hours to 7-10 days.

Hurricane is a destructive wind with a speed of more than 32 m/s, covering large areas and accompanied by various meteorological phenomena. The average duration of a hurricane is 9-12 days.

The main type of vertical air movement is tornadoes.

Tornado is an atmospheric vortex with a diameter of up to 1000 m and a rotation speed of up to 100 m/s. Its height is from 800 to 1500 m and its speed of movement is 30-80 km/h. The average duration of a tornado is 20-30 minutes, and its energy is comparable to that of a low-power atomic bomb (fig. 3).

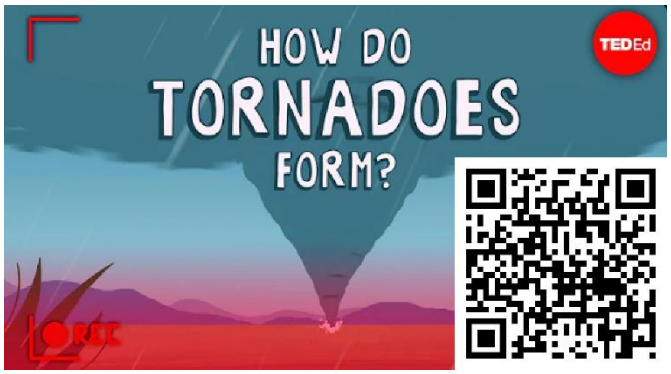


Fig. 3. Formation of a tornado. (Video 04 min 12 c)
https://www.youtube.com/watch?v=lmWh9jV_1ac

The cause of dangerous aerodynamic phenomena is cyclonic activity associated with non-uniform heat distribution and air movement from the high pressure region to the low pressure region.

Dangerous agrometeorological phenomena are caused by air temperature and precipitation.

Temperature agrometeorological phenomena include frost, very severe frost (-35°C and below), very severe heat (+35°C and above).

Agrometezrological phenomena caused by precipitation are represented by very heavy snowfall, very heavy rain (downpour), large hail. The combined effects of precipitation and air temperature result in severe ice and drought conditions.

Geological hazards include earthquake, landslide, rockslide.

Earthquakes are fluctuations of the earth's surface caused by natural or artificial factors (fig. 4).

Depending on the cause of occurrence, the following types of earthquakes are distinguished:

1. **Tectonic earthquakes –** occur when lithospheric plates collide, accompanied by surface deformation and energy release.
2. **Volcanic** – associated with plate divergence and upward flows spewing lava.
3. **Landslides** and **rockfalls -** result from landslides and rockfalls and are not very strong.
4. **Technogenic** - caused by human activity and are a form of tectonic earthquakes.
5. **Artificial -** occur in powerful explosions, the strength is determined by the amount of material blown up.

Earthquakes are defined by the following parameters:

1. **Foci** - faults in the Earth's crust, where the depth varies from 30 to 750 km. Hypocentre (underground) and epicentre (on the surface) are distinguished.
2. **Seismic energy** released as seismic waves from the hypocentre of an earthquake. Measured on the Richter scale, which includes conventional units - magnitudes (from 1 to 9.5).

Fig. 4. Most Powerful Earthquakes in Human History. (Video 09 min 4 c) https://www.youtube.com/watch?v=Kk0TaPsvP98

3. **Earthquake intensity** - external manifestations of earthquakes (tremors) in a certain area. Different scales are used for measurement. In CIS - 12-point Medvedev-Sponheuer-Karnik scale (MSK-64), in China - modified Mercalli intensity scale (MMI).
4. **Duration of seismic oscillations** of the Earth's surface. It ranges from 20-90 s

In world practice, various scales are used to determine this parameter. In Russia and CIS countries the 12-point Medvedev-Sponheuer-Karnik scale (MSK-64) is used, which was developed in 1964

As the energy of an earthquake increases, so does the area of destruction.

A landslide is a hazardous geological phenomenon characterised by the displacement of masses of rock along a slope.

A landslide is the detachment of masses of rock from the slopes of mountains.

The occurrence of rockfalls and landslides is caused by natural (increase in slope steepness, soil overwatering, seismic fluctuations) and anthropogenic (road construction, construction of heavy buildings, mining, deforestation) reasons.

Fires in natural ecosystems.

A wildfire is an uncontrolled burning that spontaneously occurs and spreads in the natural environment (fig. 5). Approximately 90% of wildfires are caused by human error.

Natural fires are classified into forest fires, peat fires and steppe fires ***according to their spread***.

According to the rate of spread, forest fires are classified into weak, medium and strong fires. The parameters of the above fires are: fire spread rate, flame height, temperature, and burn depth.

Fig. 5. Whildfires. (Video 03 min 13 c) https://www.youtube.com/watch?v=5hghT1W33cY

Lowland fires are characterised by burning of grass, shrubs, and the lower part of trees. At the initial stage of development, almost all fires are lowland fires and their transition to highland and soil (underground) fires is possible only under certain conditions.

Lower elevation runaway fires are observed in the spring, spread quickly, and have flaming burning.

Lowland steady fires occur in the summer, spread slowly, and have flameless burning.

Top fires cover the crowns of trees. They mainly occur in coniferous forests. Drought and strong winds are the main factors of highland fires.

Uphill steady fires spread slowly, producing masses of sparks and ignited material.

Highland runaway fires are characterised by long tongues of flame and spread quickly.

Soil (underground) fires are characterised by such concepts as peat forest fire and peat fire. But occur also in mines, at mines, etc.

A peat *forest fire* is a fire of the peat layer of wetland and bog soils.

Peat fire - a fire of a peat bog associated with overheating of its surface by sunlight or as a result of people's carelessness with fire. They spread very slowly, but their duration varies from several months to several years. The main combustion of peat fires is flameless. In most cases, there is no fire in these fires, and the release of large amounts of smoke is characteristic.

Steppe (field) fires spread in open areas and are associated with the burning of dry grass or mature crops. In case of burning of bread crops, slow spread of fire is noted. Steppe fires can be caused by thunderstorms, careless handling of fire, transport accidents, terrorist acts.

Biological and social emergencies include various infectious diseases. There are 3 types of infectious diseases depending on their spread among living organisms.

Human infectious diseases. Among human infectious diseases there are so-called particularly dangerous (quarantine) infections, which are characterised by: high degree of contagiousness, severe course of the disease and high probability of lethal outcome within a short period of time (fig. 6).

According to the World Health Organisation, highly dangerous infectious diseases are divided into two groups:

The first group are "diseases that are unusual in nature and may have a serious impact on the human body":

- smallpox;
- polio;
- bird flu;
- Severe Acute Respiratory Syndrome (SARS, Severe Acute Respiratory Syndrome or SARS, SARS).

The second group is "diseases that have a serious impact on the human body and are rapidly spreading internationally":

- plague (pneumonic form);
- cholera;
- ebola;
- meningococcal disease.

In Russia and Belarus, anthrax and tularemia are also considered particularly dangerous infections.

Smallpox is a highly contagious viral disease transmitted by airborne droplets and by contact with the skin or objects of a sick person, most often affecting children under 4 years of age. The disease causes ulcers on the skin and internal organs, and complications such as encephalitis and pneumonia are possible. In 1980, WHO officially declared smallpox eradicated.

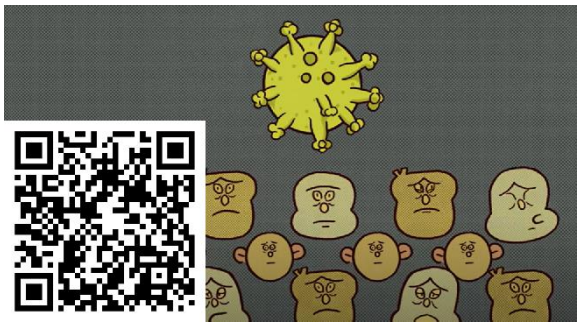


Fig. 6. The diseases that changed humanity forever. (Video 05 min 43 c) https://www.youtube.com/watch?v=Rnln3C-Las4

Poliomyelitis is an acute infection affecting the spinal cord, with a paralytic form in 1% of cases. The causative agent is a poliovirus transmitted through contaminated water and food. Children under 5 years of age are most often affected. Vaccination has reduced the incidence of the disease by 99% since 1988.

Severe Acute Respiratory Syndrome (SARS or SARS) is a viral disease that causes respiratory failure. The virus is airborne and affects not only the lungs but also the heart, liver and kidneys. The first cases were reported in China in 2002; the epidemic spread to 32 countries and was halted in 2003, with 8,465 cases and 813 deaths.

Avian influenza is a viral infection affecting the respiratory and digestive organs of birds, killing up to 90% of poultry. The virus is transmitted through water from wild waterfowl. Humans are infected by airborne and contact routes. The main risk is pulmonary syndrome with high mortality.

Plague is an acute infectious disease caused by the plague bacillus transmitted by flea bites. The disease comes in several forms: cutaneous, bubonic, septic and pulmonary.

Cholera is an infectious disease affecting the gastrointestinal tract, transmitted through contaminated water and food. The virus is excreted in faeces and vomit, including asymptomatic carriers.

Meningococcal disease is a bacterial infection affecting the central nervous system. It is transmitted by airborne droplets. It manifests as pneumonia and meningitis.

Ebola fever is a haemorrhagic fever caused by the Ebola virus. The source is bats and monkeys. The virus is transmitted through the fluids of infected animals. The 2014-2015 outbreak in Central and West Africa resulted in 27,748 cases and 11,279 deaths.

Infectious diseases of animals

Foot-and-mouth disease is a highly contagious viral disease of wild and domestic animals characterised by intoxication and ulcerative lesions of the oral cavity and skin of the extremities. Wild boars, deer, pigs, sheep, goats and cattle are susceptible to FMD. The virus is transmitted through milk, saliva and other secretions of sick animals. Infection occurs through contaminated water, feed, or air. Humans can become infected through raw milk or contact with sick animals, especially children (fig. 7).

Fig. 7. How do viruses jump from animals to humans? (Video 05 min 04 c) https://www.youtube.com/watch?v=xjcsrU-ZmgY

Newcastle disease is a highly contagious viral disease of birds. The disease affects the nervous, respiratory and digestive systems of birds, causing haemorrhages, paresis and paralysis. Chickens, turkeys and peacocks are most often affected. The virus is transmitted through the air, poultry products and contaminated objects. The disease is not dangerous for humans, causing only mild flu-like symptoms.

Classical swine fever is a highly contagious viral disease affecting domestic and wild pigs of all breeds and ages. The infection causes damage to the haematopoietic organs, lungs and intestines. The source of the virus is sick pigs that excrete the pathogen with excreta. The infection is spread through water, feed, manure and clothing. Infection occurs mainly through the gastrointestinal tract and respiratory tract, and less frequently through damaged skin. Classical swine fever is not dangerous to humans, but humans may be carriers of the virus without showing symptoms.

Mass lesion of plants by diseases and pests.

Wheat yellow rust is a harmful fungal disease affecting cereals. The main sign of the disease is light yellow oblong stripes on leaves, stems and grain. The disease causes leaf desiccation and reduced grain quality.

Potato phytophthora is one of the most widespread and dangerous fungal diseases affecting tomatoes, peppers, aubergines, buckwheat and strawberries. The infection affects all above-ground organs and tubers of potatoes, causing brown spots on leaves and dark brown streaks on stems. Later, the spots and streaks may rot or dry out, and the tubers develop dark patches that decompose.

The Colorado potato **beetle** is one of the most dangerous agricultural pests and its main food source is potatoes. The insect damages all parts of the plant, including leaves and tubers, as well as tomatoes, aubergines, sweet peppers and tobacco.

Recommendations on citizens' actions in case of threat and occurrence of natural emergencies.

Citizens' actions in case of floods. If there is rising water outside, it is necessary to leave the flats on the ground floor and go up to the upper floors (in one-storey buildings, attic rooms should be occupied). Once in the water, use objects that float or rise above the water (fig. 8).

Fig. 8. How to survive floods? | Preparing for a flood (Video 05 min 46 c) https://www.youtube.com/watch?v=pi_nUPcQz_A

Rules of behaviour in case of strong winds (storms, hurricanes, tornadoes). Close windows and doors in the house, switch off electricity. Torches, food and water supplies should be prepared. It is not recommended to stay near windows. If strong winds are outside, it is necessary to find a safe shelter.

When fighting forest fires. When extinguishing a small fire, you can use water, damp soil, dense cloth, wet clothes. If the fire centre cannot be extinguished, leave the fire zone. When travelling in a burning forest it is necessary to duck to the ground, breathe through a wet cloth or hold your breath. After leaving the fire zone, report the fire to the district administration or fire service.

2.3 Natural emergencies characteristic for the Republic of Belarus for the Republic of Belarus

The main natural emergencies on the territory of the Republic of Belarus include dangerous hydrological, meteorological phenomena and natural fires.

Dangerous hydrological phenomena are represented by strong floods in the Pripyat River basin. There is a probability of flooding of some settlements during the overflow of the rivers Western Dvina and Neman.

Meteorological hazards include: high winds, heavy rainfall, drought.

It has been established that since 1989 the average annual temperature on the territory of Belarus exceeds the climatic norm.

Strong winds and heavy precipitation are recorded practically over the whole territory of the Republic of Belarus.

Drought can be observed practically over the whole territory of Belarus.

Natural fires. Forest and peat fires are the most frequent in the territory of the Republic of Belarus. In rare cases, field fires (burning of ripe bread) are registered.

Geological hazards on the territory of the Republic of Belarus include local seismic vibration sources and echoes of the Carpathian earthquakes. Belarus is located in a stable (platform area), local seismic vibration sources are few and occur with magnitudes up to 4-6 MSK.

Biological hazard is associated with infectious diseases of humans, animals and plants. Natural foci of anthrax and rabies are the most widespread in the territory of the Republic of Belarus. The danger of mass spread of these diseases among animals and people exists in four regions of Belarus. There is also a risk of **plague** infection in Belarus.

Phytophthora massively affects agricultural plants in Grodno, Brest and Gomel regions.

Emergencies of man-made nature

A technogenic emergency is a condition in which, as a result of a technogenic emergency in a certain territory, there is a threat to human life and health, damage to the national economy and the environment.

An accident is a dangerous man-made event that threatens life and health, leads to the destruction of objects and damage to nature. If an accident is accompanied by casualties, it is called a **catastrophe**.

Technogenic emergencies are classified by the place of their occurrence (departmental affiliation) and by the nature of hazardous (striking) factors of the emergency source.

Technogenic hazard in the territory of the Republic of Belarus is associated with the presence of various industrial facilities (fire-explosive, chemically hazardous, radiation hazardous) and transport vehicles.

Industrial Facilities. ***A fire and explosion hazardous facility (FIHF)*** is a facility where flammable substances are stored or used.

A chemically hazardous facility (CHF) is a facility where hazardous chemicals are stored or used; in Belarus there are more than 500 such facilities with 40 thousand tonnes of hazardous substances, including 26 thousand tonnes of ammonia.

A radiation hazardous facility is a facility where radioactive substances are stored, used or transported. There are more than 1000 such facilities in Belarus, as well as 4 nuclear power plants near the border.

Transport means. In the Republic of Belarus, the technogenic hazard is determined by such types of transport as road, railway and pipeline transport.

Road transport. More than 22 thousand road accidents were registered on the territory of Belarus from 2012 to 2016, in which about 4 thousand people died.

Railway transport. Every month up to 1000 tank cars with flammable liquid are transported through the territory of the Republic.

Pipeline transport. The total length of pipelines in the Republic of Belarus is about 11 thousand kilometres, many of them cross roads, and there are more than 600 settlements in the vicinity.

Control questions

1. Characterise the rights of citizens of the Republic of Belarus in the field of protection from emergency situations.
2. Describe the responsibilities of the citizens of Belarus in the field of protection from emergency situations.
3. What does the term "Natural Emergency" mean? Name the groups of natural emergencies depending on the sphere of occurrence.
4. What are natural hazards? Specify hydrological, meteorological and geological hazards.
5. Formulate a definition of the term "Wildfire". Name natural fires according to their sphere of origin.
6. What are particularly dangerous infectious diseases of humans, animals and plants?
7. Characterise the hazards of natural emergencies.
8. Describe the algorithm of citizens' actions in case of threat and occurrence of natural emergencies.
9. Name the natural emergencies typical for the Republic of Belarus.
10. Specify the types of man-made emergencies.

Lecture 3. Ensuring fire safety at industrial and civil facilities

Lecture plan:

3.1. Legislation of the Republic of Belarus in the field of fire safety. The concept of fire safety.

3.2. Organizational and technical measures to ensure fire safety.

3.3. Ensuring fire safety in the operation of household electrical appliances. Prevention of fire and explosion during the operation of domestic gas equipment.

3.1. Legislation of the Republic of Belarus in the field of fire safety. The concept of fire safety

Fire safety activities are regulated by the following documents:

1. Law of the Republic of Belarus of June 15, 1993 No. 2403-XII "On fire safety".

2. Resolution of the Ministry of Emergency Situations of the Republic of Belarus No. 3 of March 14, 2014 " On Approval of the Fire Safety Rules of the Republic of Belarus. PPB 01-2014".

3. STB 11.0.02.0.02-95. System стандартовof fire safety standards. Fire safety.

The Law of the Republic of Belarus "On Fire Safety" defines (fig. 29)***:***

1. Fire safety system.
2. Legal regulation of fire safety activities.
3. State Administration in the field of fire safety.
4. Supervision and control in the field of fire safety.
5. The system of fire regulation and standardization.
6. Informing the public about fires and fire safety issues.
7. Extinguishing fires.
8. Responsibilities of republican state administration bodies, heads of organizations, employees and citizens.
9. Training in fire safety measures.
10. Rights and obligations of state fire supervision bodies.

Fire – uncontrolled burning that causes damage.

Fire safety – the location of an object that protects people and property from the impact of fire hazards.

Fire safety includes a fire prevention system and fire protection.

Fire prevention system – a set of measures and tools aimed at preventing the occurrence of a fire.

Fire protection – a set of measures, means and forces aimed at preventing and ensuring fire extinguishing, as well as protecting people and property from the impact of its dangerous factors.

The main requirements for providing fire protection are:

1. Requirements for limiting the formation of a combustible environment and preventing the formation of ignition sources in this environment.

2. Requirements for safe operation of technological equipment, ventilation and heating.

Administrative and criminal liability for violation of legislation in the field of fire safety.

Administrative responsibility is determined by the Code of Administrative Offences of the Republic of Belarus (CAO RB).

Violations and administrative liability measures:

1. Violation of the legislation on fire safety, including the requirements of technical normative legal acts of the system of fire regulation and standardization, - entails a warning or a fine in the amount of up to thirty basic units, and for a legal entity-up to two hundred basic units (Article 23.56 Part 1 of the Administrative Code of the Republic of Belarus).

2. Violation of fire safety rules by the person responsible for the implementation of these rules, which led to the occurrence of a fire, - entails the imposition of a fine in the amount of thirty to fifty basic units (Article 23.56 part 2 of the Administrative Code of the Republic of Belarus).

Criminal liability is established by the Criminal Code of the Republic of Belarus (CC RB).

Violations and measures of criminal liability against persons responsible for compliance with fire safety regulations:

1. Violation of fire safety rules that led to the occurrence of a fire, committed within a year after the imposition of an administrative penalty for violating these rules – - is punishable by a fine, correctional labor for up to one year, arrest for up to three months with or without deprivation of the right to hold certain positions (Article 304 part 1 of the Criminal Code of the Republic of Belarus).

2. Violation of fire safety rules that has caused a fire that has caused bodily injury or damage on a large scale-is punishable by correctional labor (up to two years), arrest (up to six months), restriction or deprivation of liberty (up to three years) with or without deprivation of the right to hold certain positions (art. 304 part 2 of the Criminal Code of the Republic of Belarus).

3. An act provided for in Article 304, part 2 of the Criminal Code of the Republic of Belarus, which resulted in the death of a person or causing serious bodily injury to two or more persons, - is punishable by imprisonment for a term of up to seven years with or without deprivation of the right to hold certain positions (Article 304, part 3 of the Criminal Code of the Republic of Belarus).

3.2. Organizational and technical measures to ensure fire safety

Organizational and technical measures include the responsibilities of managers, employees of organizations and citizens in the field of fire safety.

Responsibilities of the manager:

1. Ensuring control over the implementation of the Law of the Republic of Belarus "On Fire Safety" and fire safety requirements.

2. Organization of development of fire safety instructions.

3. Organization of work to ensure the safety of people in the event of a fire.

4. Creation of a system of training in fire safety requirements and organization of training of employees of the fire-technical minimum (PTM).

5. Appointment of persons responsible for the proper technical condition and operation of technological equipment, ventilation and heating systems, communication and warning equipment, technical fire protection equipment (TSPZ), as well as for the fire safety of the facility's divisions.

6. Distribution of responsibilities among employees in case of fire. Creation of voluntary fire brigades (DPS), fire-technical commissions (PTC) and organization of their work.

7. Organization of safe conduct of fire-hazardous works.

8. Organization of measures to prevent the formation of fires and taking measures to eliminate them.

9. Taking measures to determine the causes that led to the fire, and implementing measures to eliminate them in the future.

10. Organization of development of the fire safety data sheet.

11. Organization of informing employees about the state of fire safety and the risk of fire.

12. Organization of availability of stands with information on fire safety.

Responsibilities of heads of structural divisions of the object:

1. Knowledge of the object's fire hazard and measures to ensure its fire safety.

2. Maintenance of buildings, equipment, fire-fighting equipment, primary fire-fighting equipment, communications equipment, and vehicles in a technically sound condition, as well as taking measures to eliminate violations of fire-fighting requirements.

3. Take measures to ensure the evacuation of people and stop equipment in case of incidents that can lead to a fire.

4. Immediate notification to the higher management of all violations of fire safety requirements and malfunctions of fire equipment.

5. Provision of training and training of subordinate employees under the fire-technical minimum program (PTM).

6. Prohibition of admission to work of subordinate employees who have not completed fire safety training and training under the PTM program.

7. Ensuring compliance with the established fire safety regime at the facility.

8. Ensuring the correct maintenance of the TSPPZ and organizing training of workers in the procedure for using these tools.

9. Ensuring the preparation of the DPA action in case of fire.

Responsibilities of facility employees and citizens:

1. Knowledge and compliance with fire safety requirements at the facility and in everyday life.

2. Ability to apply primary fire extinguishing agents.

3. Knowledge of fire hazards, as well as the rules for safe operation, storage and transportation of the substances and materials used.

Planning of fire safety measures. Programs of economic and social development at various levels (locality, city, region, republic) provide for measures to

ensure fire safety and develop the material and technical base of the state emergency service.

Training of officials, employees and citizens in fire safety rules. The study of fire safety requirements and training in actions in the event of a fire is mandatory for educational institutions, as well as professional training and other organizations.

Educational institutions of republican state administration bodies develop and implement training programs, prepare literature on fire safety issues.

Fire-technical minimum (PTM) – a system of knowledge, skills and abilities that allows an employee of an organization to implement measures to ensure fire safety.

Objectives of the PTM training program:

1. Improving the general technical knowledge of fire safety of employees of the organization and familiarizing them with the rules of fire safety.

2. Detailed study by employees of the organization of the procedure for using primary fire extinguishing equipment and technical means of fire protection.

Mandatory training under the PTM program is subject to:

- employees of the organization responsible for ensuring fire safety;
- employees who perform duties related to conducting fire prevention training;
- employees who operate devices and units that run on various types of fuel;
- employees who perform duties related to the preparation or conduct of fire operations;
- performers of fire works;
- employees whose professional activity is related to the storage, movement, or use of flammable substances and materials;
- persons involved in harvesting grain crops;
- representatives of volunteer fire brigades, volunteer fire brigades, and fire and technical commissions.

A fire prevention regime is a set of preventive measures when performing work on an object.

Preventive measures include:

- establishing the procedure for passing the fire-technical minimum and fire-prevention briefing;
- establishing the procedure for employees ' actions when a fire is detected;
- determination of the locations and maximum quantities of raw materials and finished products in production facilities;
- regulating the procedure for conducting fire operations;
- equipment of places intended for smoking;
- determination of the procedure for disconnecting electrical equipment after the end of work;
- establishing procedures for cleaning up combustible waste and storing oiled workwear;

- regulation of the procedure for inspection and closing of industrial premises at the end of the working day;

3.3. Ensuring fire safety in the operation of household electrical appliances. Prevention of fire and explosion in the operation of domestic gas equipment

Fire safety measures for the operation of household electrical appliances:

- Carefully read the appliance's operating instructions before using it.
- use of network filters to prevent electrical appliances from catching fire due to voltage fluctuations in the network;
- installation of electric heating devices (iron, electric stove) on a fireproof surface;
- regularly remove dust from the back of the refrigerator for normal operation of the heat exchanger.

In addition, it is prohibited to:

- include a large number of electrical appliances in the network.
- leave unattended household appliances connected to the power grid (fig. 9).
- use wires with damaged insulation.
- use home-made electrical appliances for heating, drying, and cooking.
- place flammable materials near electrical appliances (TV, refrigerator, etc.).

Fig. 9. Safety rules when using household electrical appliances

An emergency mode of operation of a household electrical appliance can cause a fire. A constantly connected hair dryer in the bathroom, a forgotten iron,

careless handling of the oven - all this and much more will create dangerous situations.

When using domestic gas equipment, it is forbidden:

- leave the gas stove running unattended.
- allow children to use gas equipment;
- use gas appliances for drying things and heating the room;
- redevelopment of the premises where the gas equipment is located, without the consent of the gas supply organization;
- store cylinders of liquefied gas (propane, butane) in a residential area;
- independently replace cylinders and repair gas equipment.

If a gas smell is detected in the room, you must:

- turn off the tap on the gas stove or the cylinder valve.
- open windows for airing the premises.
- exclude the use of various ignition sources (open fire, household appliances, electric lighting);
- protect the respiratory system with a damp cloth to avoid poisoning and leave the room: This is important to prevent inhalation of dangerous gas. A wet cloth applied to the nose and mouth can help trap gas particles, reducing the risk of poisoning. Leave the room to avoid further exposure.

After these measures are taken, you should call the emergency gas safety service or the fire department to check the situation and take the necessary actions to eliminate the threat.

Control questions:

1. Name the regulatory acts that regulate fire safety activities.
2. Formulate a definition of the concepts "Fire" and "Fire safety". What is fire safety?
3. Describe the measures of administrative responsibility for violation of legislation in the field of fire safety.
4. Describe the measures of criminal liability for persons responsible for compliance with fire safety regulations.
5. Name the responsibilities of the facility manager in the field of fire safety.
6. Specify the responsibilities of heads of structural divisions, employees, and citizens in the field of fire safety.
7. What is the fire-technical minimum?
8. Describe the preventive measures that ensure a fire-fighting regime at the object.
9. Name the fire safety measures used for the operation of household electrical appliances.
10. Specify fire safety measures for the operation of domestic gas equipment.

Lecture 4. Security and Procedure citizens in case of fires in buildings

Lecture plan:

4.1. Conditions that contribute to the occurrence of fires in the housing stock. The main causes of fires at industrial and civil facilities. Dangerous fire factors

4.2. Purpose of technical means of fire protection. Primary fire extinguishing means.

4.3. Modern fire extinguishing means.

4.4. Procedure for actions of managers and citizens in the event of a fire in buildings. Features of behavior during a fire in multi-story buildings (evacuation rules, improvised means of protecting the skin and respiratory tract, safety measures when in smoke-filled rooms).

4.1 Conditions that contribute to the occurrence of fires in the housing stock. The main causes of fires at industrial and civil facilities. Dangerous fire factors

In 2018-2023, about 6,000 fires occurred annually in the Republic of Belarus, in which up to 600 people died.

Conditions that contribute to the occurrence of fires in housing stock, are created by the presence of a flammable environment and ignition sources.

A combustible environment is an external environment that ignites upon contact with an ignition source.

The combustible environment includes:

1. Interior and household items (furniture, carpets, household appliances, etc.).
2. Various materials (construction, finishing, cladding, etc.).
3. Flammable liquids (gasoline, acetone, kerosene, paints and varnishes , etc.), gas cylinders, household chemical consumables.

An ignition source is a substance that, when exposed to the external environment for a long time, is capable of causing combustion.

The main sources of ignition include:

1. Open fire (a lit match, a working burner of a gas stove, an unextinguished cigarette).
2. Heat from water heaters or electric heaters.
3. Overload or malfunction of various electrical devices.

The main causes of fires in percentage at industrial and civil facilities (Fig. 10):

- children playing with fire - 6;
- unspecified causes – 7;
- arson – 10;
- violation of fire safety rules during operation of electrical equipment – 18;

- violation of the rules for the installation and operation of heat-generating devices and units (stove heating, gas equipment, etc.) – 19;
- careless handling of fire (careless smoking) – 40.

Fig. 10. Causes of fires (Video 1 min 58 sec)
https://www.youtube.com/watch?v=BQzv9-VuG6o

Fire hazards are fire hazards that can cause injury or death to humans, material damage, or environmental pollution.

Fire hazards are divided into primary and secondary.

The primary factors of a fire include: flame and high temperature, smoke and toxic combustion products, and low oxygen content.

Flame and high temperature. Flame is a hot gaseous medium, accompanied by "glow" and heat release. During a fire, the flame temperature can reach 1500°C.

Thermal radiation of the flame contributes to the spread of the fire for tens of meters. In the zone of thermal impact, the air temperature is 60–80°C. Even with short-term exposure to this temperature, a person experiences burns of the skin and respiratory tract.

Powerful ascending heat currents are capable of carrying sparks over a considerable distance, creating new sources of fire.

Smoke and toxic combustion products. Smoke is a mixture of various combustion products, including toxic compounds.

Toxic combustion products occur during fires in modern buildings that contain a large number of polymer and synthetic materials. Thus, when foam rubber burns, hydrocyanic acid is released, when linoleum burns, hydrogen sulfide is released, etc.

The most dangerous of the toxic compounds is carbon monoxide (CO). This substance binds to blood hemoglobin 200-300 times faster than oxygen and causes oxygen starvation. In this case, the following are observed: headache, dizziness, chest pain, dry cough, convulsions, respiratory arrest and death. Death can occur as a result of 2-3 breaths in 1-3 minutes.

Reduced oxygen content. During a fire, oxygen is consumed for the combustion of various substances. Combustion products containing suspended gaseous and solid particles are mixed with air. As a result, the oxygen concentration decreases.

The content of this substance in the atmosphere is 21%. At the initial stage of a fire, the oxygen concentration decreases to 16%. It has been established that even

at 17% content of the above-mentioned substance in the air, deterioration of motor functions, impaired attention and thinking occur. At an oxygen concentration of less than 6%, death occurs within 6–8 minutes.

Secondary fire factors are:

- explosions;
- fragments and debris of building structures and equipment;
- electric current caused by loss of insulation of current-carrying parts of mechanisms.

In fires, approximately 73% of people die from exposure to toxic combustion products, about 20% *from* exposure to high temperatures, about 5% *from* reduced oxygen concentrations, and about 2% from secondary fire factors.

4.2. Purpose of technical means of fire protection. Primary fire extinguishing means

Technical fire protection equipment (TFPE) provides:

- early detection of fire;
- limiting the spread of combustion and its hazardous factors;
- extinguishing the fire before the arrival of fire departments;
- reducing the impact of hazardous combustion factors on people, economic facilities and the natural environment.

The main TFPE include primary fire extinguishing means (Fig. 11). Primary fire extinguishing means are: a fire shield, fire extinguishers, water storage tanks, a sand box, felt, and an internal fire hydrant.

Fig. 11. Primary fire extinguishing means

The fire shield is designed to accommodate fire-fighting equipment (fire extinguishers, buckets, axes, etc.). A box of sand and a barrel of water are placed near the shield. They are installed at enterprises in the absence of technical means of fire

protection (internal and external fire water supply, automatic fire extinguishing systems) and when the building is located at a distance of more than 100 m from external fire water sources.

Fire extinguishers.

Carbon dioxide fire extinguishers are used to extinguish fires of various substances and materials, as well as electrical installations under voltage of up to 1000 V. When the fire extinguisher is activated, carbon dioxide changes from a liquefied state to a solid state. As a result, a snow-like mass is formed, the temperature of which is 70°C.

After using carbon dioxide fire extinguishers, it is necessary to ventilate small rooms, since carbon dioxide in high concentrations can cause poisoning.

Powder fire extinguishers are used to extinguish fires of various substances (solid, liquid, gaseous) and fires of electrical installations under voltage of up to 1000 V.

Activation of the fire extinguisher ensures loosening of the powder. Using a powder fire extinguisher allows isolating the fire source from atmospheric oxygen.

Air-foam fire extinguishers are used to extinguish fires of solids and flammable liquids. These fire extinguishers contain a 6% aqueous solution of the foaming agent PO-1. When the fire extinguisher is activated, the foaming agent mixes with air and foam is formed. The use of air-foam fire extinguishers ensures cooling of the burning substance and its isolation from oxygen.

The water storage tanks (barrels) have a capacity of 200 liters and are equipped with a bucket and a lid. The capacity of the buckets is 8 liters.

Sand box **with** a volume of 0.5 to 3 m^3 and a shovel. Sand is used to extinguish fires on wooden objects, electrical equipment, etc.

Internal fire hydrant is used to extinguish fires of various substances and materials and is connected to a hose and a nozzle. Two people are needed to work with an internal fire hydrant. One person brings the fire hose with the nozzle to the source of the fire, the second turns on the hydrant (Fig. 12).

Fig.12. Internal fire hydrant

4.3 Modern fire extinguishing equipment

At the moment, the most attention is paid to fire extinguishing technologies using finely atomized means - water and fire extinguishing agents. Automated fire extinguishing systems have already appeared, which help prevent fires at the earliest stage. These are automatic devices that do not require human presence and are triggered when the first signs of fire occur. They monitor the air temperature in the room, report the start of a fire using light and sound, transmit a signal to the fire equipment control sensors, eliminate smoke in the area where people will be evacuated, and supply fire extinguishing agents to the fire zone. After receiving a fire signal, the devices activate sprinkler modules, quickly and efficiently extinguish the fire. To extinguish flames, automated systems use: freon, foam, carbon dioxide, water, emulsion, powder.

For the correct use of modern fire extinguishing means, it is necessary to take into account the type of structure, the material that prevails in the upholstery and objects located inside the building and the technical features of the device. Before choosing and installing equipment, a detailed assessment of the categories of possible fire, building, new fire extinguishing technologies is made.

The most common and effective are water devices for extinguishing flames. To extinguish a wooden building, sprinkler automation systems are used. A sprinkler is a valve located in a container that has the ability to perceive an increase in temperature (Fig. 13). The device is a container made of thin glass. The glass cracks

when the temperature increases, and the water inside pours out of this container and extinguishes the flame in localized areas.

Fig. 13. Water sprinkler fire extinguishing (Video 1 min 27 sec)
https://www.youtube.com/watch?v=dar49NOKGiM

Sprinklers are mounted indoors under the ceiling on a water pipe that is under pressure.

A new principle in modern automatic fire extinguishing systems is considered to be devices that use fine sprayed water particles to extinguish flames. Fine-dispersed equipment creates water droplets that can reach the most remote corners of a building. This effectively extinguishes the fire and eliminates smoke.

In residential buildings, institutions, and warehouses, powder fire extinguishing devices can be installed. In such buildings, local equipment is installed. Non-toxic powder is supplied to the fire zone. This equipment has a short service life because the powder can cake and deform.

But after such extinguishing of the fire, there is no negative effect on the material of the lining and objects in the room. After the effect of the powder, you only need to clean up, and the devices and things will remain undamaged.

When extinguishing a flame, powder is sprayed. A cloud is created that blocks oxygen from reaching the fire, which extinguishes it. The powder is placed in special cylinders under pressure.

The self-acting powder device extinguishes fire quickly and does not require human presence. This equipment is harmless to human health and does not harm the environment. The systems are universal and inexpensive compared to other devices.

The most common and convenient fire extinguishing systems are gas devices. Automatic gas installations act on the source of the fire with a fire extinguishing gaseous substance. Such installations are used in buildings where there is an increased risk of damage to valuable property, devices, equipment. Self-acting fire extinguishers impacts are installed where there is a possibility of electric shock.

The operation of gas fire extinguishing systems is convenient due to the large temperature range of objects where such devices are used. Non-flammable gas is supplied to the local zone of the fire source. Such equipment also allows localizing the flame in a large area.

After detecting a fire, such an automatic system turns on the fire alarm. After that, people must evacuate from the danger zone. Then the fire extinguishing gas

supply system is activated. After the fire is extinguished, it is only necessary to ventilate the building to let the gas escape.

There are also foam devices. They provide maximum safety, the list of headings of the capabilities of this system include: speed, efficiency, safety. They are used in buildings where there are flammable materials, flammable liquids, at oil and gas industry facilities. To extinguish a fire at such facilities, a longer effect is required.

The backpack fire extinguishing system RUPT – 1-0.4 has proven itself well. Extinguishing fluid: water with foaming composition. Backpack units have an exceptionally high efficiency of extinguishing fires of all classes (A, B, E). During certification tests, a model fire of rank 15A was extinguished, which corresponds to a burning area of 67 square meters. The fire was extinguished with only 10 liters of extinguishing agent. The unit allows for effective extinguishing of spills of any flammable liquids with an area of about 30 square meters, as well as live electrical installations, electrical cables and cable routes.

Aerosol units are used at sites with a large number of electrical devices, vehicles, and energy companies. The disadvantage of such devices is their high price and the fact that their impact reduces visibility at the fire site.

4.4. Procedure for actions of managers and citizens in case of fire in buildings. Features of behavior in case of fire in multi-story buildings

Actions of the facility manager in the event of a fire:

1. Checking the call of fire departments, volunteer fire brigades. Sending responsible persons who know the location of access roads and water supply sources to meet fire departments.

2. Taking measures to prevent panic, organizing the evacuation of people, calling for medical assistance if necessary.

3. Organization of fire extinguishing using primary fire extinguishing means and the use of technical fire protection equipment.

4. Organization of measures to protect people involved in extinguishing the fire.

5. Power outage, stoppage of transport devices, units, storage facilities, shutoff of gas communications, stoppage of ventilation systems, activation of smoke removal systems.

6. If possible, evacuate material assets.

7. Upon arrival of the fire department, the facility manager is obliged to inform the fire extinguishing manager of the following information: the location of the fire, the presence of people in the premises, the presence of explosive and fire hazardous materials and the measures taken to extinguish the fire.

Actions of citizens in the event of a fire:

1. Call 101 or 112 to report the address and location of the fire.

2. Organize activities to alert and evacuate people.

3. Take measures to extinguish the fire using primary fire extinguishing means.

Features of behavior during a fire in multi-story buildings:

1. If you smell smoke or flames, call the Ministry of Emergency Situations at 101.

2. When the rooms are filled with smoke, you should go to the exit or to the smoke-free staircase. You should move while bending over, holding on to the walls or railings. To protect yourself from fire and toxic combustion products, you can use a handkerchief, towel, or clothing soaked in water.

3. In case of fire, it is not recommended to use the elevator. This is due to damage to the electrical wiring or the elevator being disconnected (Fig. 14).

Fig. 14. Rules of conduct for citizens in the event of a fire in a multi-story building.

4. Once in a crowd, you must: bend your arms at the elbows, press them to your sides and clench your fists. At the same time, you need to lean your body back,

resting your legs forward. These actions are designed to hold back the pressure of the crowd with your back.

5. If it is impossible to leave the room due to heavy smoke and high temperature, you must return immediately. Door cracks and ventilation openings must be covered with wet cloth.

6. If the smoke concentration and temperature in the apartment increase, you should go out onto the balcony, closing the door tightly. To protect yourself from fire if it penetrates through the door or window openings, you can use a wet blanket or carpet.

7. If there is no fire downstairs and it is dangerous to remain in the room, then you can use tightly tied ropes, sheets or curtains and try to go down to the floor below.

Control questions:

1. Describe the conditions that contribute to the occurrence of fires in residential buildings.
2. Name the main causes of fires at industrial and civil facilities.
3. Specify the primary and secondary factors of fire.
4. Describe the primary factors of fire.
5. Name the primary fire extinguishing means.
6. Describe the different types of fire extinguishers.
7. What is a fire shield?
8. Describe the procedure for the facility manager to follow in the event of a fire.
9. Describe the actions of citizens when a fire occurs.
10. Describe the specific behavior during a fire in multi-story buildings.

Lecture 5. Prevention of emergencies at chemically hazardous facilities, organization and maintenance of chemical protection measures

Lecture plan:

5.1. Definition of the term "chemically hazardous object". Ensuring safe operation of chemically hazardous facilities. Classification of organizations and territories by chemical hazard level.

5.2. Brief description of the most common emergency chemical hazardous substances (ammonia, chlorine, hydrogen cyanide), their impact on the human body.

5.3. Main measures for the prevention of emergencies at chemically hazardous facilities. Organization and composition of chemical protection measures. Personal and collective protective equipment.

5.1. Definition of the term "chemically hazardous object". Ensuring safe operation of chemically hazardous facilities. Classification of organizations and territories by chemical hazard level

A chemically hazardous object is an object intended for storage, processing, use, or transportation of chemically hazardous chemicals (CHF), where an accident can cause chemical contamination or death of people, as well as chemical contamination of the environment.

Chemical hazardous objects include:

- chemical and oil refining enterprises;
- food industry enterprises;
- sewage treatment plants;
- railway stations that carry out various technological operations (loading, unloading, etc.) from CHF.
- warehouses of toxic chemicals for the destruction of insect pests and rodents.

Groups of measures to ensure the safe operation of chemically hazardous objects:

1. Management of technological processes.
2. Operation of monitoring, control and emergency protection systems, communications and alerts.
3. Organization of storage and discharge of liquefied gases, flammable and combustible liquids.
4. Maintenance and repair of equipment.
5. Labor protection measures.

Let's take a closer look at the characteristics of groups.

1. Management of technological processes:

- Various regulatory and technical documents should be developed based on the project. The development of technological regulations establishing the procedure for the technological process is carried out in coordination with Gospromnadzor;

- the technological process diagram should be placed within the boundaries of the workplace or attached to the technological instructions for this workplace;
- technological systems and pipelines that handle combustible products that can form explosive mixtures with air must be sealed;
- when using solid dusty substances, air dustiness control should be organized, as well as systematic monitoring of the serviceability and tightness of technological equipment and ventilation systems;
- in systems for the transport of explosive and fire-hazardous substances, where deposits on the internal surfaces of pipelines are possible, it is necessary to organize the cleaning of these deposits;
- people and traffic should be restricted in potential areas of destruction.
- organization of control over the presence of combustible impurities in the non-flammable liquid to be discharged into the sewer system;
- Research and development work may be carried out in accordance with Gospromnadzor, if there is project documentation and an independent expert opinion.

2. Operation of monitoring, control and emergency protection, communication and notification systems:

- it is prohibited to conduct the technological process and operate equipment with faulty or disabled means of control, automation and emergency protection, as well as in the absence of the above-mentioned means;
- for the period of replacement of elements of the control or management system, measures are provided to ensure the safe conduct of the process in manual mode;
- organization of control over the correct operation of warning and communication systems, control systems, and control systems;
- organizations that have explosion-and fire-hazardous facilities in their composition should organize systematic monitoring of the serviceable condition of measuring and automation equipment, control systems and emergency protection;
- in the locations of control, management and emergency shutdown systems, as well as communications and notification, various harmful effects that affect the accuracy and speed of systems must be excluded: contamination by process products, mechanical impacts, vibration.

3. Organization of storage and discharge of liquefied gases, flammable and combustible liquids:

- railway tank cars intended for filling and transportation of flammable and combustible liquids must be equipped with control devices, draining and filling devices and protective devices;
- when draining railway tank cars, measures should be taken to prevent their spontaneous movement, depressurization of the draining devices, as well as excluding the presence of ignition sources (mechanical, electric, etc.);
- to prevent the overflow of flammable and combustible liquids, railway tank cars and automobile tanks must be equipped with reliable automatic devices.

4. Maintenance and repair of equipment:

- equipment that has operational documentation and has passed the entrance control is allowed to operate.
- technological systems must be sealed. For equipment with possible leaks of combustible substances, the technical documentation specifies the permissible values of these leaks, and organizes their collection and removal.
- devices for connecting mobile electrical equipment are located outside hazardous areas. The level of explosion protection of this equipment must correspond to the class of explosive zone;
- when carrying out work on cleaning the equipment, cleaning agents (mechanical, hydraulic, chemical) should be used, excluding the presence of people in the equipment;
- operation of equipment that has reached the established service life is allowed upon receipt of a conclusion on technical reliability and the possibility of its further operation;
- assessment of the quality of equipment repair is determined by the customer and contractor of the repair with the participation of an employee of the technical supervision of the enterprise and is indicated in the act of equipment delivery from repair.

5. Labor protection:

- personnel safety is ensured by compliance with: general requirements for labor protection, requirements of various regulatory legal acts, labor and technological discipline;
- employees of chemical hazardous facilities should be provided with personal protective equipment;
- the head of the organization is obliged to ensure control over the use of personal protective equipment by employees;
- employees of explosion-and fire-hazardous facilities of the organization must work and wear special clothing and special shoes that do not allow the accumulation of static electricity (electrification when two different substances come into contact) and spark formation;
- when performing various jobs, it is necessary to use a tool that does not give a spark on impact. Tools and equipment must be explosion-proof.
- if a liquid leak is detected due to a malfunction of equipment or pipelines, it is necessary to immediately fix the problems and remove spilled products.

Classification of organizations and territories by chemical hazard level. According to various estimates, there are between 341 and 540 chemically hazardous facilities in the Republic of Belarus. The depth of distribution of some emergency chemically hazardous substances may exceed 20 km. In total, more than 2.3 million people may be in potential chemical contamination zones (PCCZ) in Belarus. There are 4 degrees of chemical hazard (Table 2).

Table 2

Classification of organizations, territories by degrees of chemical hazard

Chemical hazard level	Number of people in the zone of possible chemical contamination	Number of settlements in the PCCZ	List of populated areas
I	75 thousands	2	Grodno, Novopolotsk
II	40–75 thousands	7	Gomel, Volkovysk, Slonim, Novogrudok, Borisov, Slutsk, Rogachev
III	less than 40 thousands	12	Lida, Molodechno, Mozyr, Soligorsk, Minsk, Mogilev, Bobruisk, Orsha, Zhodino, Zaslavl, Smorgon, Svetlogorsk
IV	the affected area does not extend beyond the object	–	–

5.2 Brief description of the most common accident and chemical hazardous substances (ammonia, chlorine, hydrogen cyanide), their impact on the human body

An emergency chemical hazardous substance (ECHS) is a dangerous chemical substance used in industry and agriculture, which may cause environmental contamination if released in an emergency. The total stock of ECHS in the Republic of Belarus is 46 thousand tons.

The most common accidentхимически опасным and chemical hazards include ammonia, chlorine, and hydrogen cyanide (hydrocyanic acid).

Ammonia (NH_3) is a colorless gas with a pungent odor, almost twice as light as air. Ammonia mixed with air is flammable and explosive.

In mammals and humans, the above compound is rapidly converted to urea. Ammonia provides a normal acid-base balance of the blood. In addition, this substance is one of the main sources of nitrogen for living organisms.

At a temperature of -33.35°C and normal pressure, ammonia liquefies into a colorless liquid. At a temperature of -77.75°C, it freezes to form a colorless crystalline mass. Ammonia dissolves very well in water.

Liquefied ammonia and an aqueous solution of ammonia are used as nitrogen fertilizer. In the food industry, the above chemical compound is used as a refrigerant. In medicine, ammonia is used as a disinfectant for hand washing and the production of ammonia. Ammonia contains up to $10\%_{NH3}$.

Liquid ammonia is a good solvent for a very large number of organic and inorganic compounds. This substance is also used for the production of soda, explosives and for dyeing fabrics.

Storage and transportation of ammonia is carried out in a liquid state under pressure in steel cylinders.

Depending on the damaging effect on the body, this compound belongs to the group of substances of suffocating and neurotropic action.

When inhaled, ammonia can cause swelling of the larynx, lungs and severe damage to the nervous system. A person can die in a few hours or days after poisoning. If liquefied ammonia comes into contact with the skin, chemical burns or frostbite may occur.

Chlorine (Cl_2) – is a greenish-yellow gas with a pungent odor. This element is 2.5 times heavier than air. The chlorine cloud moves by pressing down on the ground. At normal atmospheric pressure and a temperature of -34°CC the substance condenses into a yellow liquid. Freezing of chlorine with the formation of a yellowish crystalline mass is observed at the usual pressure and temperature of -102°C. It is water-soluble.

Chlorine occurs only as compounds in minerals. The most common compound of this element is sodium chloride (NaCl). In certain areas, it forms large deposits in the form of rock salt.

Chlorine compounds are part of all living organisms. In humans and animals, chlorine ions, together with sodium and potassium ions, participate in the regulation of water-salt metabolism. Sodium chloride is necessary for the production of hydrochloric acid in the stomach. Magnesium chloride activates vitamins, enzymes, and antibodies.

Chlorine is also necessary for the vital activity of plants. This element contributes to the formation of oxygen during photosynthesis.

Chlorine is used for the production of bleach used for disinfection, bleaching of fabrics and paper pulp, disinfection of drinking water, in the production of chemical weapons, synthetic rubber used in the manufacture of rubber products, polyvinyl chloride (PVC), from which plastic products are made, пecpesticides for controlling weeds and harmful insects etc.

Store and transport chlorine in steel cylinders and railway tanks under pressure.

Chlorine belongs to the group of asphyxiating substances. Exposure to high concentrations of the above substance on the human body for 15 minutes can lead to the development of chemical burns of lung tissue, suffocation and death. Very high concentrations of chlorine within a few minutes lead to paralysis of the respiratory center and death. In addition, chemical burns and frostbite of the skin can occur when exposed to this substance (fig. 15).

Fig. 15. Symptoms of chlorine in water

Prussic acid (hydrogen cyanide, HCN) is a colorless, highly volatile liquid with the smell of bitter almonds. A mixture of hydrogen cyanide vapors and air explodes when ignited. This compound is highly soluble in water.

It is also called hydrogen cyanide. When interacting with alkalis, the above acid forms cyanide salts.

Prussic acid is found in bitter almonds, apricots, apples, pears, plums, and cherries. In addition, this substance is a component of tobacco smoke and is released during the thermal decomposition of synthetic fibers (nylon, polyurethane).

Hydrogen cyanide is also found in the human body. Neurons play an important role in the production of this compound. Hydrocyanic acid provides signal transmission between nerve cells. It is also онasecreted by white blood cells. Hydrogen cyanide can destroy pathogenic microorganisms.

This compound is a raw material for the production of plastics, rubber, synthetic fibers, plexiglass, plant growth stimulants, pesticides, pharmaceuticals, and aromatic substances. In addition, solutions of hydrocyanic acid can be used as disinfectants, in the development of photographs, in the extraction of gold and silver.

This acid is stored and transported in a liquid state in cylinders and railway tanks.

Depending on the damaging effect on the body, hydrogen cyanide is classified as a substance of general toxic action. This substance in the human body blocks the ability of red blood cells to transport oxygen. Hydrogen cyanide causes damage to the nervous, respiratory and cardiovascular systems. At very high concentrations, due to paralysis of the respiratory center, death can occur within a few minutes.

In case of accidental release, the above substances are characterized by low resistance to contamination, as they quickly evaporate. At the same time, pairs of these connections can be detected at a distance of several kilometers.

5.3 Main measures for the prevention of emergencies at chemically hazardous facilities. Organization and composition of chemical protection measures. Personal and collective protective equipment.

The main measures to prevent emergencies at chemically hazardous facilities include:

1. Location of dangerous objects at a safe distance from residential buildings.
2. Improving the reliability of production control systems in the field of industrial safety.
3. Control and improvement of the fire safety system.
4. Improvement of security systems based on the results of emergency forecasting.

Organization and composition of chemical protection measures. There are two main principles of protecting the population from emergencies at chemically hazardous facilities:

1. advance training of state emergency management bodies and forces and training of the population in ways to protect against the damaging effects of emergency and chemically hazardous substances;
2. a differentiated approach to the choice of methods of protection from CHF, taking into account the degree of danger to human habitation.

Early preparation is determined by measures to prevent emergencies at chemically hazardous facilities. These events include:

- identification and elimination of emergency causes;
- maximum reduction of possible damage and loss of life;
- creating conditions for the fastest possible elimination of the consequences of an emergency.

The differentiated approach includes:

- analysis of the emergency situation on the detour;
- availability of time, effort, and resources.

Ways to protect the public from chemically hazardous substances:

1. Timely notification of the population.
2. Use of personal and collective protective equipment.
3. Temporary shelter for people in residential and industrial buildings.
4. Evacuation from hotbeds of chemical contamination

Personal and collective protective equipment. Personal protective equipment (PPE) protects the respiratory organs and skin from exposure to toxic substances, radioactive dust and bacterial agents.

PPE is classified according to four main criteria:

1. ***By destination:***

- personal respiratory protection equipment (PRPE);
- skin protection products (SPP);
- medical protective equipment.

2. ***Based on the protection principle:***

- filtering – the air entering the respiratory system is cleaned of harmful impurities.
- insulating – provide protection of the respiratory system from harmful impurities that are not retained by filter masks.

3. *By manufacturing method:*

- industrial – made in advance.
- the simplest (improvised) ones are made by the population itself.

4. *By security forms:*

- report cards – intended for providing formations of the state system of prevention and elimination of emergency situations;
- non-portable – designed to equip formations and the population.

Pre-trial detention facilities include: gas masks, respirators, anti-dust fabric masks (ADFM) and cotton-gauze bandages (CGB).

Gas masks, in comparison with respirators, protect not only the respiratory organs, but also the scalp from exposure to dangerous substances. These protective devices can be filtering or isolating.

In *filter* gas masks, the contaminated air is cleaned by a filter-absorbing box. This device is installed on the front of the gas mask. Do not use when the oxygen content in the air is less than 16-18% (Fig. 16).

Fig. 16. Filter gas mask

The principle of operation *of insulating* gas masks is to completely isolate the human body from the outside air. Respiration is carried out at the expense of oxygen coming from a regenerative cartridge or oxygen cylinder. Insulating gas masks are used at high concentrations of toxic substances, as well as in conditions of lack of oxygen.

Respirators belong to the pre-trial detention center of the filter type. These protective equipment is designed for use with less air pollution than when using gas masks. Respirators do not provide protection against chemical warfare agents (fig. 17).

Fig. 17. R-2 respirator

Dustproof fabric masks (fig. 18) and cotton-gauze bandages are the simplest means of respiratory protection. To protect them from potentially hazardous substances, they must be pre-moistened with water. Weak solutions of acids and alkalis can be used to increase the protective properties.

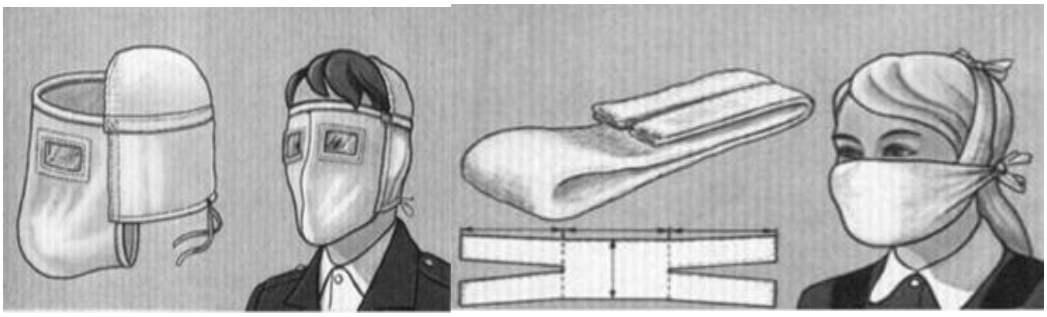


Fig. 18. Anti-dust fabric mask

Skin protection products are divided into service and improvised.

Service vehicles can be isolating and filtering. There are two types *of insulating* materials: sealed (suits, overalls) and leak-proof (capes, aprons). They are made of rubberized fabric and covered with special gas-and moisture-proof films. *Filter* materials include cotton coveralls impregnated with special chemicals (for neutralization or sorption of toxic substances and CHF vapors).

Improvised means of protection include samples of everyday clothing (capes, raincoats, mittens, boots). To increase the protective properties of the above-mentioned clothing, they are impregnated with a special chemical composition (for example, a soap-oil emulsion).

The main means of medical protection include an individual anti-chemical package and an individual dressing package.

The individual anti-chemical package is used for disinfection of toxic substances and emergency and chemically hazardous substances that have fallen on open areas of the skin, clothing and personal protective equipment.

An individual dressing bag is used to apply aseptic dressings to wounds, stop bleeding, and also as a means of immobilization in case of injuries.

Collective protection means include: shelters and refuges (anti-radiation, protozoa).

A shelter is a hermetically sealed structure that protects people from CHF, bacterial agents, all the damaging factors of a nuclear explosion, as well as from high temperatures and toxic substances in the fire zone.

These structures are usually constructed from monolithic, precast-monolithic, or precast reinforced concrete. In some cases, bricks and other stone materials are used to build shelters. The choice of material is determined by the capabilities of the local industry and economic feasibility.

There are **6 main signs of shelters**:

1. ***By destination:*** general purpose and special purpose. *General purpose shelters* include structures designed to protect employees of enterprises and the public, both in urban and rural areas.

Refuges of *special purpose shelters* are designed to accommodate government agencies and medical institutions.

2. ***By capacity:*** large (over 2000 people), medium (from 600 to 2000 people), small (up to 600 people).

3. ***According to their protective properties***, shelters are divided into 5 classes, depending on the excess pressure of the blast wave and the degree of radiation attenuation (Table 3).

Table 3

Classification of shelters by protective properties

Class	Air blast wave overpressure (kgf/ cm2)	Degree of attenuation of penetrating radiation
1	5	5000
2	3	3000
3	2	2000
4	1	1000
5	0,5	350

4. ***According to the construction time, shelters are divided into pre-erected (PES) and quickly erected (QES).***

PES are built taking into account peacetime plans and using strong fireproof materials. The construction of these structures is carried out in 9-12 months. with a capacity of 1000 people or more.

QES are created with the declaration of a threat of an emergency. Construction is carried out from prefabricated structures within two days. Facilities of this type are primarily provided to enterprises that continue to operate in the city in wartime conditions.

5. ***By location:*** built-in and detached.

Built-in shelters are built in basements, basements, and ground floors of buildings. They must be located under buildings with the lowest number of floors.

Separate shelters are created if you can't set up built-in shelters. Free-standing shelters at the top and sides are sprinkled with soil, which provides protection from

penetrating radiation and high temperature in case of fires. Underground passages, subways, and mine workings can be adapted for this type of structure.

6. ***By equipment:*** with industrial equipment; with simplified equipment (manufactured by the manufacturer).

Anti-radiation shelter – a structure that provides conditions for sheltering the population in order to protect them from contamination with radioactive substances, as well as from direct contact with clothing and skin with drops of toxic substances, emergency chemicals and aerosols of bacterial agents.

Anti-radiation shelters are designed to protect the population of rural areas and small towns. They can be placed in any basement, basement or ground floor of buildings. Also in cellars and vegetable storage facilities, passages, mines, and mining workings.

For the construction of the above-mentioned shelters, materials such as precast reinforced concrete structures, bricks, wood, stone, and brushwood are used. The capacity of these structures varies from 5 to 300 people or more, depending on the area.

It is established that the first floors of a multi-story stone building can weaken the effect of radiation by 5-7 times. Basements of a multi-story building weaken radiation by 500-1000 times, and wooden houses-by 7-12 times.

The simplest shelters – are structures that provide partial protection of the population from the damaging factors of a nuclear explosion, as well as protect against direct contact with clothing and skin of toxic substances.

Construction of structures of this type is carried out when there is a shortage of shelters and radiation shelters. Trenches, crevices, and earthworks, as well as the interior of buildings, basements, cellars, and underground passages are used as the simplest basic protective structures.

Control questions

1. Formulate a definition of the term "Chemically hazardous object".
2. Name some chemically hazardous objects.
3. Specify groups of measures to ensure the safe operation of chemically hazardous facilities.
4. Describe the degree of chemical hazard.
5. Describe the use of emergency and chemically hazardous substances in human economic activities.
6. What changes occur in the human body when exposed to chemically hazardous substances?
7. List the methods of protecting the population from hazardous chemical substances.
8. Name the personal protective equipment.
9. Please indicate respiratory protection and skin protection.
10. List the collective protection measures.

Lecture 6. Conditions requiring first aid. Stopping breathing and blood circulation, measures to revive the body

Lecture plan:

6.1. Definition of the concept of "first aid". General principles of providing first aid to victims in emergency situations.

6.2 List of conditions requiring first aid. The concept of clinical death. Respiratory and circulatory arrest.

6.3. Determination of signs of human life in the absence
consciousness. Sequence of events
to revive the body

6.1. Definition of the concept of "first aid". General principles of providing first aid to victims in emergency situations.

First aid is a set of simple measures carried out directly at the site of injury as self- and mutual aid, as well as by participants in emergency rescue operations.

First aid measures are aimed at preserving the lives of victims of injuries, poisoning and sudden illnesses.

The goal of first aid is to prevent the development of severe complications. The basis of first aid measures is made up of 3 principles:

- correctness and appropriateness;
- speed and care;
- determination and calmness.

First aid measures include:

1. Immediate cessation of exposure to damaging factors (temperature factor, electric current, compression by weights, etc.).

2. Providing first aid depending on the type and nature of the injury (stopping bleeding, measures to revive the body, etc.).

3. Organization of transportation of the victim to a medical facility in accordance with the type and nature of the injury.

First aid is effective only if it is provided as soon as possible after the injury. The optimal time for providing this aid after receiving an injury is from 5 minutes (if breathing has stopped) to 1 hour.

In case of serious damage, the maximum compensatory functions of the body maintain a stable state for 1 hour. Later, as a result of gradual depletion of strength reserves, the body strives to provide the brain with the remains of vital forces.

According to the World Health Organization, 30% of victims with life-threatening injuries die within an hour of an accident without first aid at the scene.

6.2. List of conditions requiring first aid. The concept of clinical death. Respiratory and circulatory arrest

Terminal conditions are pathological changes in the human body, characterized by the progressive destruction of all tissues.

These conditions are characterized by profound disturbances of gas exchange. Since different tissues react differently to the cessation of oxygen delivery to them, their death does not occur simultaneously. The highest section of the central nervous system, the cerebral cortex, is most sensitive to hypoxia. In terminal conditions, the functions of this section of the CNS are switched off first. After the cortex is switched off, changes are also observed in the subcortical sections of the brain. The medulla oblongata, which performs the functions of respiration and blood circulation, is the last to die.

The causes of the development of terminal conditions include: traumatic shock, acute blood loss, electrical injury, burns, drowning, myocardial infarction, etc.

Terminal states represent the process of dying of the organism, the transition from life to death. Dying of the human organism includes 3 stages.

Pre-agony is a terminal condition characterized by the development of inhibition in the higher parts of the central nervous system.

Consciousness is preserved, but its confusion and obscurity are noted. Eye reflexes are preserved, despite the decrease in reflex activity. At the beginning of pre-agony, a short-term excitement may occur, explained by the body's attempt to fight for its life.

Blood pressure is low (up to 60 mm Hg) or not detectable. Heart rate changes are noted - from increase (tachycardia) to decrease (bradycardia). Pulse in peripheral arteries is very weak or absent (pulse is detectable in carotid and femoral arteries).

Breathing is initially rapid and deep, then shallow and rare. Respiratory disorders are manifested by pallor and cyanosis (blueness) of the skin.

In addition, there is a sharp decrease in body temperature and the absence of urine excretion by the body (oliguria). Duration The pre-agonal state is determined by the body's capabilities and ranges from several minutes to a day.

The pre-agony ends *with a terminal pause*. Breathing stops, the pulse is rare, sometimes absent. Bradycardia is observed, sometimes asystole (cessation of cardiac activity). Loss of consciousness is observed 4-5 seconds after cardiac arrest. Pupil reactions to light disappear, pupils dilate. Respiratory and cardiac arrest are short-term.

The duration of the terminal pause is from a few seconds to 5 minutes. At the end of the above-mentioned state, agony sets in. Since the terminal pause occurs rarely, it is not included in the classification of the stages of the organism's death.

Agony is a stage of dying characterized by profound dysfunction of the higher parts of the central nervous system, especially the cerebral cortex. At this stage, the body's compensatory mechanisms are activated, aimed at combating the fading of vital forces.

In the state of agony, there is a short-term recovery, and then loss of consciousness. The pupils do not react to light, the pupils are dilated. There is no pain sensitivity.

The pulse in the peripheral arteries is not determined and is felt only in the carotid arteries. Bradycardia and absence of arterial pressure are noted.

Breathing is characterized by rare, short and deep convulsive breathing movements. Swallowing of portions of air is observed. As a result of weakening of the respiratory muscles and accumulation of mucus in the bronchi, breathing becomes hoarse. Sharp pallor of the skin and cyanosis in the limbs are noted.

In addition, a decrease in body temperature and involuntary release of urine and feces are observed.

The duration of the agonal state varies from several minutes to 6 hours. In the absence of first aid, the above stages of the body's dying pass into one another and end in clinical death.

Clinical death is a reversible stage of dying, a transitional period between life and death.

Consciousness is absent, pupils are dilated. Breathing, blood circulation and pulse are not determined. Sharp pallor and coldness of the skin are noted.

Despite the above signs, metabolic processes continue in the body. The duration of clinical death is 3-7 minutes. During this period, it is still possible to restore vital functions with the help of resuscitation measures. At a later stage, the death of cerebral cortex cells occurs, and clinical death turns into biological death.

Subsequently, measures to revive the situation no longer yield results.

The main factors influencing the duration of clinical death include the duration of dying, age and resuscitation methods.

In chronic arterial hypotension (low blood pressure), the prolongation of the preagony and agonal periods makes resuscitation virtually impossible. In cases of rapid dying (acute blood loss, electrical injury, drowning), the duration of clinical death is prolonged, since severe irreversible changes do not have time to develop in the organs and tissues.

In elderly people with chronic diseases, the duration of clinical death is shorter than in young, healthy people. The duration of clinical death is also determined by the methods of resuscitation. Use of an artificial blood circulation apparatus allows you to revive the body even after 20 minutes of clinical death.

6.3. Determining signs of life in a person without consciousness. Sequence of measures to revive the body

Determination of any sign of life is an important condition for carrying out first aid measures.

Signs of life in the absence of consciousness include:

1. Presence of pulse.
2. Presence of heartbeat.
3. Presence of breathing.

4. Presence of pupillary reaction to light.

1. Presence of a pulse. In the absence of consciousness, the pulse should be determined only on the carotid arteries. The carotid artery is one of the largest in the human body. It is possible to determine the pulse on this artery even at the lowest pressure.

To determine the pulsation of the carotid arteries, you need to place your fingers in the area of the laryngeal cartilage and also move your fingers to the right or left.

2. Presence of a heartbeat. The heartbeat is determined by the absence of a pulse on the carotid artery with a hand or ear on the left half of the chest.

3. Presence of breathing. Breathing is determined by the movement of the chest and anterior abdominal wall. If this is not possible, the presence of breathing is determined by bringing objects that fog up from the breath to the victim's mouth or nose. Such objects include: a mirror, a watch, glasses, a knife blade, a piece of glass, etc.

Breathing can also be determined by the movement of a piece of cotton wool held to the nostrils.

4. The presence of a pupillary reaction to light. The pupils of a living person dilate in the dark and constrict when exposed to light.

Pupil constriction during the daytime is determined as follows:

- if a person's eyes are closed, then his eyelids are raised;
- If a person is lying with their eyes open, then the eyes are covered with a hand for some time (from 5–10 seconds to 2–3 minutes), and then the hand is quickly moved to the side.

In the dark, to determine the reaction of the pupils, it is necessary to illuminate the eye with any light source.

Sequence of measures to revive the body. Resuscitation, or resuscitation, is a set of emergency measures aimed at restoring blood circulation and breathing when they suddenly stop.

There are 3 stages of carrying out measures to revive the body (Fig. 19).

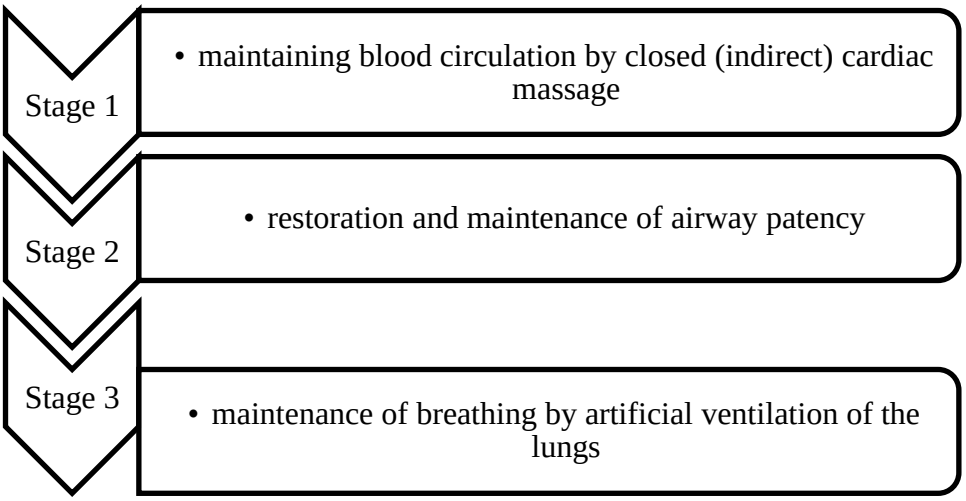


Fig. 19. Measures to revive the body

Maintaining blood circulation by closed (indirect) cardiac massage.

1. The victim must be on a firm, level surface (table, couch, floor). This surface must be used to prevent the victim's body from shifting during indirect cardiac massage. It is also necessary to raise the patient's legs to ensure blood flow to the brain.

2. The location of the hands is two transverse fingers above the end of the xiphoid process of the sternum.

When performing closed cardiac massage, the hands can be placed one on top of the other "crosswise" (Fig. 20) or "locked" (Fig. 21). When using the "crosswise" method, the fingers should be raised. The hands are positioned perpendicular to the sternum and should not be bent at the elbows. The support is provided on the base of the palms.

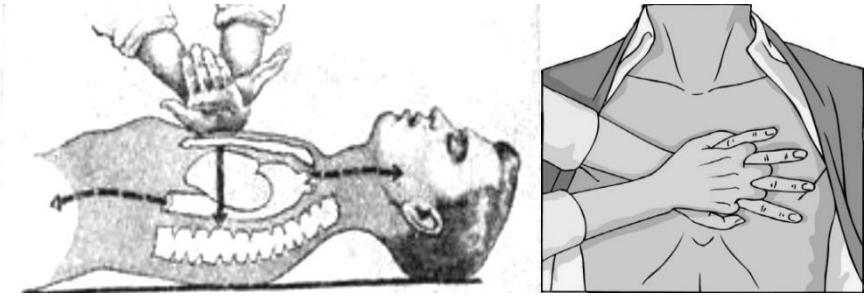


Fig. 20. The position of the hands "cross- cross" Fig. 21. The position "hands in a lock"

3. Indirect cardiac massage should be performed vigorously, in a push-like manner, due to the weight of the upper half of the body. In this case, blood is pushed out of the heart chambers through the vascular bed. When performing compression, it is unacceptable to shift the palms relative to the sternum. Closed cardiac massage is performed at a frequency of 100–120 per minute and with the sternum shifted 5–6 cm toward the spine.

Compression is performed taking into account the age characteristics of the body. Indirect cardiac massage in children is performed at a frequency of 100 per minute to a depth of up to 5 cm. In addition, compression is performed on infants with two fingers, and on older children - with one palm.

Resuscitation measures can be started with a single precordial blow.

Restoring and maintaining airway patency. At this stage, Safar's triple technique is performed:

1. Throwing the head back.
2. Forward protrusion of the lower jaw.
3. Opening the mouth.

The head is tilted back as follows: one hand is placed under the victim's neck and raised as high as possible. The other hand is placed on the forehead and pressed on the head (Fig. 22).

With the above manipulations, not only does the root of the tongue move away from the back wall of the larynx, but also the mouth partially opens. Throwing the head back ensures the restoration of airway patency.

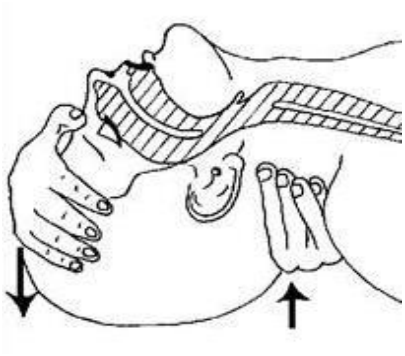


Fig. 22. Head tilt

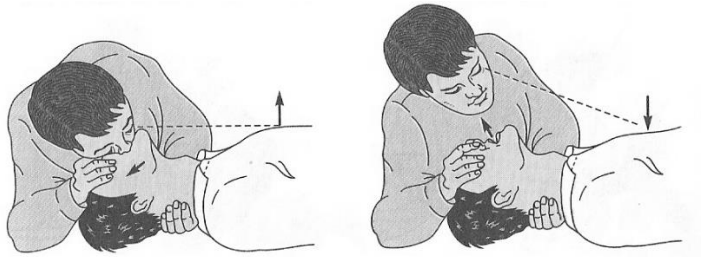
Moving the lower jaw forward and opening the mouth. After throwing the head back, grasp the victim's lower jaw near the auricle with both hands. Then pull the lower lip with the thumbs and move the lower jaw forward. This results in an even greater opening of the mouth (Fig. 23).

If there is a suspicion of a cervical spine injury (car accident, fall from a height, etc.), it is recommended to limit yourself to just pushing out the lower jaw. If this does not ensure free airway patency, then, regardless of the injury, the head is thrown back. When performing the triple Safar maneuver, it is necessary to examine the oral cavity and, having seen a foreign body (fragments of teeth, a fallen out denture), remove it. For this, you can use a bandage, handkerchief, napkin.

Fig. 23. Protrusion of the lower jaw and opening of the mouth

Maintaining breathing by artificial ventilation of the lungs. There are two main methods of artificial respiration: "mouth-to-mouth" and "mouth-to-nose".

When performing artificial ventilation using the *mouth-to-mouth method*, pinch the victim's nose, take a deep breath, tightly cover the patient's lips with your lips and exhale. The duration of air blowing should be 1 second. Exhalation into the victim's oral cavity should not be too sharp or large. Air blowing should be accompanied by visible movement of the chest. After these measures, it is necessary to free the patient's nose. The interval between breaths should be 4-5 seconds. When blowing air for hygienic purposes, the victim's mouth should be covered with a handkerchief (Fig. 24).



a b

Fig. 24. Artificial respiration using the mouth-to-mouth method: a – inhale; b – exhale

Artificial respiration using the "mouth-to-nose" method is performed in cases where the patient's mouth cannot be opened (during convulsions, when the lower jaw is damaged, etc.). To perform this method of artificial ventilation, the victim's mouth is closed, a deep breath is taken, the patient's nose is tightly covered with the lips and the breath is exhaled into it. As soon as the chest has risen, the victim's nasal cavity is freed and his mouth is slightly opened, allowing free exhalation.

The compression/breathing ratio is 30:2, regardless of the number of people performing resuscitation. When performing resuscitation, it is necessary to assess the patient's breathing and pulse every 2 minutes (Fig. 26).

Fig. 26. Performing artificial respiration. (Video 3 min 41 sec) https://www.youtube.com/watch?v=wUJ-BIEY7H0

Resuscitation is more effective when performed by two rescuers.

Resuscitation activities involving two people are carried out almost continuously and are characterized by uniform distribution of physical load. When providing resuscitation care, rescuers must be changed frequently and quickly.

One of the rescuers constantly holds the victim's head in a tilted position, performs artificial ventilation of the lungs, determines the pulse on the carotid arteries, and counts chest compressions out loud.

Signs of the effectiveness of measures to revive the body include:

1. Restoring the pulse in the carotid artery.
2. The appearance of pupillary reaction to light.
3. Restoring breathing.
4. The emergence of consciousness.

The criteria for terminating resuscitation measures are:

1. The emergence of a danger to the health of rescuers.
2. No signs of effectiveness of measures to revive the body within 30 minutes.

Control questions

1. Formulate a definition of the concept "First aid". Specify the purpose and principles of first aid.
2. Name the measures to provide first aid.
3. What are called terminal states? Specify the main terminal states.
4. Describe the pre-agonal terminal state.
5. What is terminal agonal state?
6. Describe the changes in the human body that occur during clinical death.
7. Formulate a definition of the concept "Resuscitation". Name the measures to revive the body.
8. Describe the measures for performing indirect cardiac massage.
9. How can the victim's airway be restored?
10. What is artificial ventilation?

Lecture 7. First aid for electric shock, lightning, flame burns, frostbite, drowning

Lecture plan:

7.1. Flame burns and frostbite. Sequence and content of first aid measures.

7.2. Effect of electric current on the human body. Sequence and content of measures to provide first aid.

7.3. Drowning. Types of drowning, features of first aid in case of true drowning.

7.1. Flame burns and frostbite. Sequence and content of first aid measures

A burn is damage to human tissue caused by exposure to high temperatures, electric current, hazardous chemicals and radioactive radiation.

There are two main classifications of burns: by type of damage and by depth of damage.

By type of damage:

Thermal burns are injuries caused by exposure to high temperatures. The main factors causing the injury are: flame, liquid, steam, hot objects.

Electrical burns are burns that result from exposure to electric current.

Chemical burns are damage caused by chemically active substances (alkalis, acids).

Radiation burns are burns that occur when exposed to various types of radiation (light radiation, ionizing radiation).

Depending on the depth of damage to human body tissue, there are four degrees of burns.

First-degree burns are characterized by superficial damage to the upper layer of the epidermis. The above-mentioned burns are accompanied by reddening of the skin, slight swelling, and pain. The burn injury heals in 2–4 days without any traces of damage.

Second-degree burns are characterized by complete damage to the superficial layer of the epidermis. This is accompanied by pain and the formation of small blisters containing clear liquid. This burn heals in 1–2 weeks without scarring.

Burns of grades III A and III B are distinguished.

In case of *grade III A burns* all layers of the epidermis are damaged. Partial damage to the dermis is also noted. A soft or dry crust (burn scab) of light brown color is formed at the site of the lesion. The above-mentioned burns are manifested by a decrease in pain sensitivity, tissue swelling, and the formation of large blisters with dark yellow contents. If the burn injury is not complicated by infection, then there is a possibility of independent restoration of the skin surface. Healing of the burn is noted after 3-4 weeks with the formation of a scar.

Burns III B degrees are mainly characterized by total destruction of the skin and partial damage to the subcutaneous fat. Dense dark brown scabs and blisters filled with dark red liquid form on the surface of the skin. Slow healing of the burn

with scar formation is noted. Decreased sensitivity of the skin may persist even after recovery.

For burns IV degree, damage to the skin, subcutaneous fat, muscles and bones occurs. Dark brown or black burn scabs form at the site of the lesion. The duration of this burn injury is 3-4 months. With fourth-degree burns, extensive scars and long-lasting ulcers remain. Elimination of various tissue defects is ensured by skin grafting (Fig. 27).

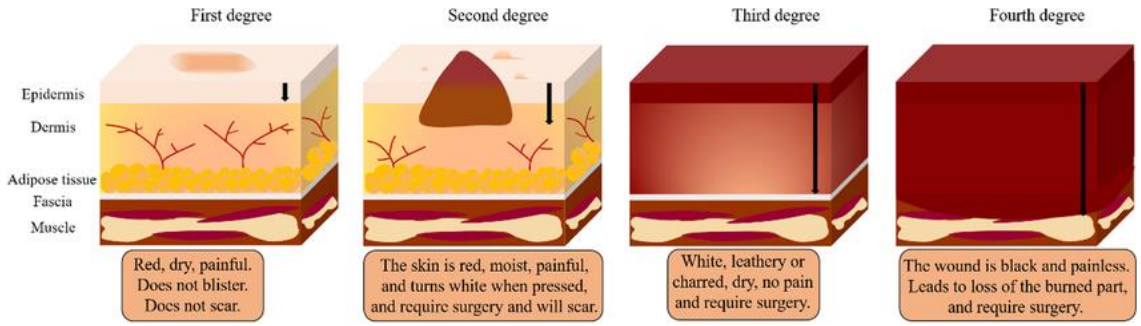


Fig. 27. Burns by depth of damage

Flame burns are the most common by type of damage**.** These burns occur due to careless handling of fire. Flame burns are most dangerous in closed spaces. This is due to the fact that in addition to burns of the skin, there are also damage to the respiratory tract from hot smoke.

Along with flame, burnt clothing poses a great danger to human skin. Unnoticed threads of burnt clothing can lead to the development of an infection. When exposed to tissue, flame causes moisture to evaporate and protein to coagulate. Prolonged exposure to flame on the skin leads to its contractions and ruptures.

The sequence and content of measures to provide first aid for flame burns:

1. Put out burning clothes on a person. When clothes catch fire, a person starts to rush about, fanning the flames. To provide assistance to the victim, it is necessary to stop. When putting out the flame, you can use any available material (jacket, coat, blanket, etc.) or pour water on the burning person. It is necessary to remove the victim from the fire zone.

2. Free the victim from smoldering clothing. The negative impact of high temperature on the skin is determined by the duration of pressing smoldering clothing to it. The remains of this clothing that are not fixed in the wound must be cut and carefully removed from the victim.

3. Cover the burn surface with a dressing or improvised material. For small-area burns of the first and second degrees, an aseptic (sterile) bandage must be applied to the damaged area of skin. For extensive burns of the third and fourth degrees, the victim must be wrapped in a clean sheet without undressing him. In this case, the patient must be warmly covered, given warm tea to drink and ensured rest until the ambulance team arrives.

Frostbite is damage to human body tissue caused by adverse environmental factors (low air temperature, high humidity, strong wind).

Most frostbite occurs at temperatures of -10° C and below. At the same time, in regions with high humidity, cold injury can occur at temperatures from -5 to 0°C.

With prolonged and intense exposure to low temperatures, persistent vascular spasm and circulatory disorders occur. In addition to low temperatures, the following factors contribute to circulatory disorders and frostbite: tight shoes or clothing, alcohol and smoking, diabetes, atherosclerosis, blood loss and general weakness of the body.

Fig. 28. Frostbite, Causes, Signs and Symptoms, Diagnosis and Treatment (Video 05 min 21 sec) https://www.youtube.com/watch?v=tPEj-0sKZyo&t=119s

In 95% of cases, cold injuries affect the extremities, mainly the lower ones. The damaging effect does not extend above the wrist or ankle joints and is limited to the fingers. This is due to insufficient blood supply to the peripheral parts of the extremities compared to other tissues and organs of the human body.

When exposed to low temperatures, not only the skin is damaged, but also all tissue components of the frostbitten part of the body (Fig. 28). This must be taken into account in order to avoid making comparisons between burns and frostbite.

To provide timely and correct assistance to victims of frostbite, cold injuries are divided into ***four degrees of severity depending on the depth of tissue damage.***

Frostbite of the first degree occurs with short-term exposure to low temperatures. The damaged area of the skin turns pale. After warming up, the skin takes on a reddish tint and becomes edematous. The above mentioned frostbite is accompanied by burning, tingling, numbness, itching and pain. Damaged tissues are restored in 5-7 days.

Frostbite of the second degree occurs with a longer exposure to low temperatures. A characteristic sign of this frostbite is the formation of blisters filled with clear liquid. Significant pain is noted, and skin sensitivity remains impaired for a long time. Skin healing occurs within 1–2 weeks.

Frostbite of the third degree is characterized by damage to all layers of the skin. Blisters containing bloody fluid appear at the site of the lesion. Rejection of damaged tissues is completed in 2-3 weeks. The nail plate is mainly subject to this effect. If the nails are not rejected, they grow deformed. Scarring lasting up to 1 month is observed later. Unlike frostbite of the second degree, the pain is more intense and prolonged.

Frostbite of the fourth degree is accompanied by damage to the skin, subcutaneous fat, muscles and bones. This cold injury is combined with frostbite of the second and third degrees. Frostbite of the fourth degree is characterized by severe pain, significant swelling, loss of sensitivity and the absence of blisters. The damaged area of the skin is sharply bluish. The duration of the process of rejection of the

damaged limb is about 1.5-2 months. Treatment of cold injury of the fourth degree leads to amputation of the frostbitten part of the body.

First aid measures for frostbite include 2 stages:

Stage 1 – before warming up the affected part of the body;

Stage 2 – after warming up the affected part of the body.

At stage 1 it is necessary to stop the effect of cold on the victim's body and restore blood circulation in the injured limb.

The victim should be brought into a warm room, and then remove clothing and shoes. When the surface layers of the skin are quickly warmed, the deep layers are warmed more slowly and blood flow is poorly restored in them. Thus, in case of frostbite, it is not recommended to use hot baths, heating pads, or hot water bottles.

A cotton-gauze or woolen bandage is applied to the injured limb. The woolen bandage must be applied over the cotton fabric. If noticeable warmth appears, the bandage should be removed. Rest is created for the injured part of the body and the victim is provided with hot sweet tea.

At stage 2, a dry sterile or ironed bandage is applied to the injured limb. If the pain is severe, the victim is given a painkiller. After the above measures have been taken, it is necessary to immobilize the affected part of the body and deliver the patient to a medical facility.

7.2. Effect of electric current on the human body. Sequence and content of measures to provide first aid.

Electric current is the directional movement of electrons in a conductor. In metals, which are typical conductors, when an electric field is applied to the conductor (for example, when the conductor is connected to a voltage source), the electrons begin to move in the direction of the field.

The main factors influencing the outcome of electric shock include:

1. ***Current magnitude.*** The smallest magnitude of electric current that causes noticeable irritation (itching, slight tingling) in the human body is 1 milliampere (mA), or 1 volt (V). However, there is no direct relationship between the magnitude of the current and its damaging effect. In addition, there are no completely safe threshold values of voltage and current. However, as the magnitude of the electric current increases, the severity of the damage also increases. This is due to the increase in the number of electrons and their interaction with the body's cells (Fig. 29).

2. ***Duration of current exposure***. The longer the duration of current exposure to the human body, the greater the likelihood of a fatal outcome. The most dangerous duration of electric current exposure is 1 s or more. This value coincides with the duration of the cardiac cycle (0.8 s).

With an increase in current and the duration of its flow through the human body, an increase in local heating of the skin is observed. This leads to the expansion of blood vessels and an increase in sweat secretion. An increase in the moisture content of the skin is accompanied by a sharp decrease in electrical resistance. Various injuries (abrasions, cuts) also reduce the electrical resistance of the skin.

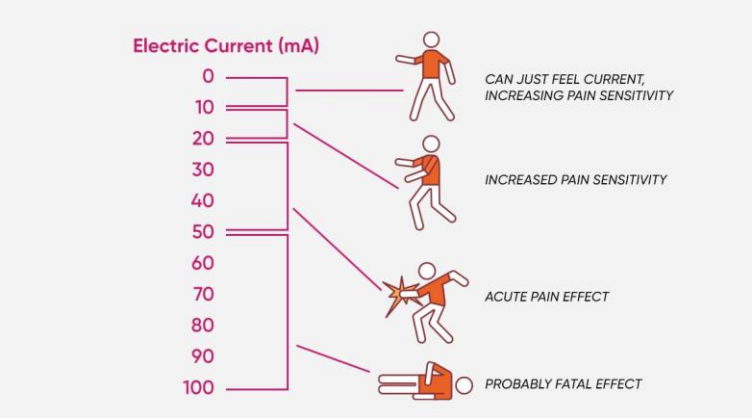


Fig. 29. The effect of electric current on the human body

3. ***Individual characteristics of the body***. The most susceptible to the effects of electric current are people suffering from diseases of the skin, nervous and cardiovascular systems, respiratory organs, and endocrine system. The severity of electric shock increases in a state of alcoholic intoxication.

There are 4 types of effects of electric current on the human body:

- ***The thermal effect of the curren*t** causes skin burns, as well as rupture of nerves and blood vessels.
- ***The biological effect of electric current*** is characterized by irritation of living tissue, which is accompanied by convulsive contraction of muscles.
- ***When mechanically impacted,*** as a result of sharp convulsive contractions of muscles, ruptures of the skin, nerves, blood vessels, as well as bone fractures and even torn limbs are observed.
- ***The electrolytic (chemical) action of current*** consists of the decomposition of blood and other organic fluids, which is accompanied by a change in their physical and chemical composition. The effect of electric current on a person leads to electrical injuries.

Electrical trauma is a complex of injuries resulting from damage by natural or technical electricity. According to static studies, electrical trauma is distributed as follows:

– 20% – local damage (electrical burns, mechanical damage, electrical signs, skin metallization, electro-ophthalmia)

– 25% – general injuries (electric shock)

– 55% – mixed electrical injuries

An electrical burn is the most common electrical injury. There are two types of electrical burns depending on the conditions of occurrence:

1. *Current (contact) burns* are observed when in contact with the current-carrying part of high-voltage electrical installations (up to 2000 V). Current burns mainly refer to burns of the first and second degrees.

2. *Arc burn* is caused by voltage over 2000 V. This phenomenon is characterized by high temperature – over 3500° C. Arc burns are burns of the III and IV degrees.

Mechanical damage is associated with a person's prolonged exposure to voltage in electrical equipment up to 1000 V. The mechanical action of current is characterized by involuntary convulsive contraction of muscles.

Electrical marks (electrical tags). When in close contact with a live part of an electrical installation, oval-shaped spots of 1 to 5 mm in size are formed. Electrical marks can be pale yellow or gray. There are marks in the form of scratches, warts, calluses, etc. Electrical marks are formed as a result of necrosis (death) of the affected areas of the skin. The surface of the mark has no inflammation, is painless and ends in healing.

Skin metallization is observed when the skin is damaged by small particles of molten metal under the action of an electric arc. During electrometallization, a skin burn occurs. The damaged area of the skin has a dark shade and is characterized by hardness and soreness. In a relatively short time, the affected skin acquires elasticity and a normal appearance.

Electro-ophthalmia is characterized by inflammation of the outer membranes of the eye under the influence of intense light (mainly ultraviolet) radiation of an electric arc. The development of inflammatory processes is noted 4-8 hours after ultraviolet irradiation. It is accompanied by sharp pain in the eyes, lacrimation, purulent discharge from the eyes, partial loss of vision. In most cases, the inflammation lasts for several days.

Electric shock is the general effect of electric current on the human body, leading to involuntary convulsive contractions of various muscles of the body, disruption of the cardiovascular and respiratory systems.

Depending on the consequences of electric shock, electric shocks include 5 stages:

1. Mild muscle spasm.
2. Convulsive contraction of muscles, characterized by severe pain. The person is conscious.
3. Convulsive contraction of muscles. Loss of consciousness is noted. Breathing and cardiac activity are preserved.
4. The victim is unconscious. Breathing and heart function are disrupted.
5. Respiratory and circulatory arrest (clinical death).

The sequence and content of measures to provide first aid in case of electric shock:

1. Free the victim from the current. It is necessary to turn off the electrical installation using a switch or circuit breaker and provide other light sources.

If it is impossible to turn off the installation, it is necessary to cut the wires with an axe with a dry wooden handle. In addition, the wires can be cut with a tool with insulated handles. A person who has been electrocuted can be pulled away from the electrical installation by grabbing his clothes. It is not recommended to touch wet clothes and exposed parts of the victim's body.

If a person who has been electrocuted is squeezing wires tightly with his hands, it is necessary to unclench his hands by bending each finger separately. To carry out this measure, insulate your hands with dielectric gloves, a scarf, a shawl,

etc. To insulate yourself from the ground, you can use rubber boots, a dry board, a bundle of clothes, etc. The wire that the victim is touching can be thrown away with the help of various non-conductive objects (a dry wooden stick, a board, etc.).

2. Assess the condition of the victim and, if necessary, begin measures to revive the body.

If the patient is conscious but has been under electric current for a long time, he should be laid on a mat of clothes and provided with complete rest until the doctors arrive . In this case, it is necessary to continuously monitor the pulse and breathing. The negative impact of the current may not appear immediately, but after several hours or even days.

If a person who has been electrocuted is unconscious , but has a steady pulse and breathing, he is placed on a mat, his clothes are unbuttoned, and fresh air is provided. In this case, the face should be sprayed with water, cotton wool soaked in ammonia should be brought to the nose, and breathing and pulse should be constantly monitored. The victim must be provided with complete rest and an ambulance team should be called immediately.

If the patient is unconscious, breathing poorly (arhythmically, convulsively), but the pulse is detectable, it is necessary to begin artificial ventilation of the lungs.

If the victim is unconscious, has no breathing, or has no pulse (clinical death), it is necessary to immediately begin measures to revive the body (artificial respiration, indirect heart massage).

If vomiting occurs, the victim's head and shoulders should be turned to the side to remove the vomit. In case of burns, a sterile bandage should be applied.

Features of damage by atmospheric electricity (lightning) during lightning discharges, first aid. Lightning voltage fluctuates from tens of millions to a billion volts. The duration of an atmospheric discharge is 7-8 seconds.

Human injury from atmospheric electricity is often observed in open spaces. Lightning causes fires in trees and transformer installations.

Damage caused by atmospheric discharge is divided into primary and secondary. **Primary injuries** occur as a result of a direct lightning strike on a person. **Secondary injuries** occur through working electrical devices that become current conductors when an atmospheric discharge hits them.

Lightning is characterized by thermal and mechanical damaging effects. Deep charring of tissues, skin ruptures, convulsions, respiratory and circulatory arrest are observed. A specific sign of lightning is tree-like light pink or red stripes covering a significant area of skin. Direct lightning strikes a person result in limbs being torn off or the body being fragmented.

First aid for victims of atmospheric discharge consists of artificial ventilation of the lungs and indirect heart massage. After the patient's breathing is restored, burns must be treated, hot tea must be given to drink, and the patient must be taken to the hospital.

7.3. Drowning. Types of drowning, features of first aid in case of true drowning

Drowning is a terminal condition caused by water entering the respiratory tract. There are 4 types of drowning:

1. ***True drowning*** is characterized by the entry of a large amount of water into the respiratory tract and lungs. If the capillaries begin to collapse under the pressure of the water, it enters the blood. Within a few minutes after the fluid enters the lungs, pulmonary edema and severe hypoxia (lack of oxygen) occur. In addition to the lungs, water enters the stomach and intestines. Wet drowning often occurs in people who cannot swim.

True drowning is divided into **three stages:**

1.1 Initial stage. The victim retains consciousness and the ability to hold his breath during repeated immersions in water. Cyanosis is noted. Breathing is rapid, coughing fits, abdominal distension and vomiting occur due to the entry of a large amount of water into the gastrointestinal tract. High blood pressure and tachycardia are replaced by a decrease in pressure and bradycardia. After drowning, weakness, headache, dizziness and cough are noted for several days.

1.2 Agonal stage. The victim is unconscious. Respiratory movements and heart contractions are preserved. The pulse is determined only in the carotid and femoral arteries. The skin has a sharp blue tint and is cold to the touch. A foamy pink liquid is released from the nasal cavity and mouth. Swollen veins of the neck and forearms are sometimes observed.

1.3 Clinical death. This stage is characterized by the absence of breathing, pulse, and pupillary response to light. The victim's appearance is the same as in the agony stage. In clinical death, measures to revive the body are not successful.

2. ***Asphyxial drowning*** is caused by a spasm of the larynx as a result of irritation of the receptors located in the respiratory tract by water. In the above-mentioned drowning, water does not enter the lungs and gastrointestinal tract. There is a cessation of air access to the lungs - asphyxia. If this condition under water continues for a long time, it is accompanied by clinical death. In this case, there is a great danger to the human body, since water gradually penetrates the respiratory tract. Asphyxial drowning is caused by a state of alcoholic intoxication, sudden fright, a strong blow to the water with the head or stomach.

This type of drowning does not have an initial stage. At a water temperature of 18–20° C, the duration of clinical death is 4–6 minutes. This is somewhat longer than in true drowning. Resuscitation measures at the stage of clinical death are not successful.

3. ***Syncopal drowning*** occurs as a result of vascular spasm and reflex cardiac and respiratory arrest. This type of drowning is caused by the effect of cold water on the skin, the entry of a small amount of ice water into the respiratory tract, strong emotional shock (fear of immersion in water), falling from a height. In addition, syncopal drowning is observed in cases of water allergy, various heart and lung diseases. This type of drowning occurs mainly in women and children.

In this type of drowning, the stage of clinical death is most pronounced. Breathing, pulse, and pupillary response to light are absent. Spasm of skin capillaries causes paleness of the skin. There is no release of foamy fluid from the respiratory tract. At a water temperature of 18–20° C, the duration of clinical death is more than 6 minutes. In drowning in icy water, the duration of this stage increases by 3–4 times.

4. **The mixed type of drowning** includes features of the true and asphyxial types. The decisive factor in saving people from drowning is the time factor. Within a minute after drowning, 90% of victims can be saved, after 6-7 minutes – 1-3%.

The main methods for extracting a drowning person from the water include (fig. 30)**:**

1. Method of throwing.
2. The method of pulling.
3. Rescue by swimming.
4. Carrying a drowning person.

Fig. 30. How to treat drowning (Video 02 min 06 sec) https://www.youtube.com/watch?v=Hlrbio-NpxQ

1. The throwing method is used if the victim is close to the shore and there are objects suitable for rescue (lifebuoy, inflatable mattress, board) nearby. This object is thrown so that the victim can grab onto it.

2. The pulling method is carried out using objects that can be tied to floating equipment or extended to the victim (a strong stick, an oar, a rope).

3. Swimming rescue. This method is used in cases where the drowning person is far from the shore. At the first stage, you need to reach the drowning person by swimming, taking a floating device with you. Then you need to stop at some distance from the victim and hand him the above-mentioned device. The floating device must be held between you and the drowning person. Then the victim can be pulled out of the water onto the shore.

4. The drowning person is carried out in the following way. The drowning person's head is kept above water by grasping a floating device. Using the rescue device, the victim can be swum to shallow water. The person, pulled out of the water, is then carried to the shore by hand or dragged.

When rescuing a victim, it is necessary to observe personal safety measures. It is necessary to swim to a drowning person only from behind, in order to avoid grabbing him. The victim should be grabbed by the armpits and, supporting his face above the water, swim to the shore (Fig. 31).

Features of first aid in case of true drowning:

1. Removing fluid from the respiratory tract. To perform this procedure, the person removed from the water must be placed with his stomach on the leg bent at the knee joint, and pressure must be applied to the chest in the area of the lower ribs. At the same time, the victim must be patted on the back.

2. Carrying out measures to revive the body if the victim is not breathing.

3. Ensuring delivery of a person removed from the water to a medical facility.

Fig. 31. First aid for drowning. (Video 02 min 32 sec) https://www.youtube.com/watch?v=W6E_ePBCzOA

Control questions

1. Formulate a definition of the term "Burn". Characterize burns by the depth of damage.
2. Describe the sequence and content of measures to provide first aid for flame burns.
3. What is called frostbite? Describe the degrees of frostbite depending on the depth of tissue damage.
4. Describe first aid measures for frostbite.
5. What is the effect of electric current on the human body?
6. Describe the measures to provide first aid in case of electric shock.
7. Describe the features of first aid in case of drowning.

2. Radiation safety

Lecture 8. Radioecological situation in the Republic of Belarus after the Chernobyl disaster

Lecture plan:

8.1. Analysis of the causes of the disaster, its development and elimination.

8.2. Direction of propagation of the radioactive cloud and the nature of radioactive contamination of territories.

8.3. Paths of external and internal irradiation of the population living in the radioactive contamination zone. Half-life and brief characteristics of the main radionuclides.

8.4. Assessment of the economic damage caused to the country by the Chernobyl disaster.

8.1. Analysis of the causes of the disaster, its development and elimination

Analysis of the causes of the disaster. The Chernobyl Nuclear Power Plant (CNPP) is located in the north of Ukraine, 8–11 km from the border with the Republic of Belarus (Fig. 32).

The station had 4 power units with RBMK-1000 type nuclear reactors (high-power channel reactor). The total reactor load was 180–190 tons of nuclear fuel (uranium-235 and uranium-238). The Chernobyl NPP was one of the most powerful nuclear power plants in the USSR, as were the Leningrad and Kursk NPPs (Fig. 33).

On April 26, 1986, an accident occurred at the 4th power unit of the Chernobyl Nuclear Power Plant during an experiment. The purpose of the experiment was to test the possibility of cooling the active part of the reactor in the event of loss of the main power source.

Fig. 32. Geographical location of the Chernobyl Nuclear Power Plant

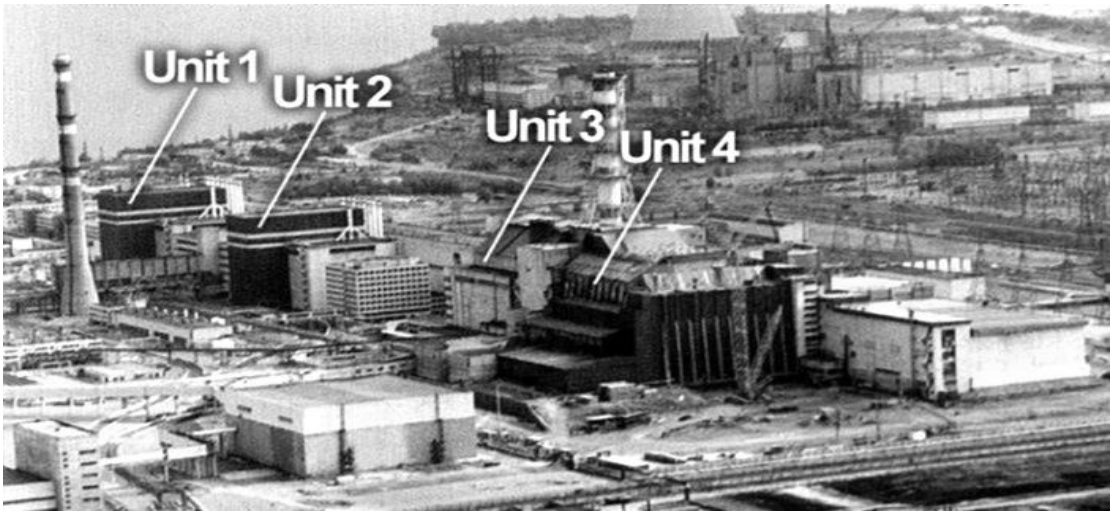


Fig. 33. Chernobyl nuclear power plant

The disaster at Unit 4 of the Chernobyl Nuclear Power Plant was caused by the following reasons:

1. Design flaws associated with violations in the design of the RBMK-1000 nuclear power plant (NPP).
2. Violations during construction (in installation technology).
3. Errors in the experimental program.
4. Unprofessional actions of the personnel of the 4th power unit of the Chernobyl Nuclear Power Plant in conducting the experiment.

1. The main design flaws of the RBMK-1000 nuclear power plant were:

- a large amount of thermal energy accumulated in the metal structures and graphite masonry of the reactor;
- imperfection of the reactor emergency shutdown system;
- lack of protective shell.

2. Violations in installation technology. It was established that some of the pipes in the 4th power unit of the Chernobyl Nuclear Power Plant were made of steel, not zirconium (work on the construction of the power unit had to be completed by the next congress of the CPSU, and there were no zirconium pipes). Steel pipes are less heat-resistant than zirconium ones, so when the temperature increased significantly, they deformed and made it impossible to regulate the reactor power.

3. Errors in the experimental program are related to the change in the operating mode of the reactor emergency cooling system (CAOP) and the shutdown of the ECCS. This experiment was not coordinated with specialists responsible for the safety of the nuclear reactor.

4. Unprofessional actions of the personnel in conducting the experiment. The removal of almost all control and protection rods from the reactor core, as well as the reduction in the flow of coolant, led to an increase in steam and a steam explosion that destroyed the reactor core. A second explosion, which occurred 2 seconds later, only worsened the destruction (Fig. 34).

Development of the disaster. As a result of two explosions, the reactor of the 4th power unit of the Chernobyl Nuclear Power Plant was completely destroyed.

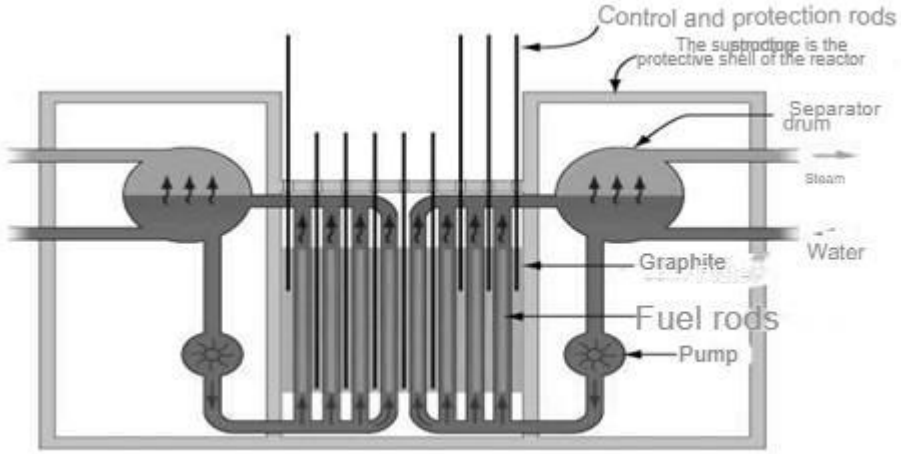


Fig. 34. Reactor of the 4th power unit of the Chernobyl Nuclear Power Plant

The first explosion was recorded at 1:23:44 a.m., the second explosion at 1:23:46 a.m. The explosions at Unit 4 were accompanied by a fire. In the first days after the accident,
4–8 tons of radioactive substances were released into the environment. In addition, 120–130 tons of fuel (long-lived radionuclides) and 700 tons of radioactive reactor graphite entered the environment in the subsequent period. In total, about 450 different types of radionuclides were released into the air, 20 of which were considered the most important (Table 4). Emissions from the reactor continued for approximately 20 days. The most intense emissions of radioactive substances were recorded during the first 10 days.

According to the International Scale of Radiation Accidents, the Chernobyl accident is classified as a level 7 radiation accident and is a global catastrophe. The height of the release of radioactive substances was 1.5–2 km. Radioactive contamination of various areas was uneven. The unevenness of contamination is due to factors such as the duration of radioactive emissions from the reactor, changes in wind direction and direction of the radioactive cloud, and the presence of precipitation.

Table 4

Radionuclides released as a result of the Chernobyl disaster

Nuclides	Total emissions, %	Half life
Xenon-33	100	5.3 days
Iodine-131	50–60	8.0 days
Cesium-134	20–40	2.0 g
Cesium-137	20–40	30 years old
Tellurium-132	25–60	78 h

Strontium-89	4–6	52 days
Strontium-90	4–6	28 years old
Barium-140	4–6	12.8 days
Molybdenum-99	more than 3.5	67 h.
Ruthenium-103	more than 3.5	39.6 days
Ruthenium-106	more than 3.5	1 g
Zirconium-95	3.5	1.4 h.
Cerium-141	3.5	33.0 days
Cerium-144	3.5	285 days
Neptunium-239	3.5	2.4 g
Plutonium-238	3.5	86 years old
Plutonium-239	3.5	24400 years
Plutonium-240	3.5	6580 years
Plutonium-241	3.5	13.2 g
Curium-242	3.5	163 days

Measures to eliminate the Chernobyl disaster:

1. Fire extinguishing.

2. Dropping up to 5 thousand tons of various materials from helicopters to absorb neutrons, heat and reduce the amount of emitted particles (Table 5).

Table 5

Materials used to eliminate the Chernobyl disaster

Material	Quantity, t	Purpose of application
Boron compounds	40	Neutron absorption
Lead	2400	
Sand and clay	1800	Absorb heat and reduce the amount of emitted particles
Dolomite	600	

3. Creation of a tunnel under the reactor to supply liquid nitrogen (cooling) and prevent the entry of radioactive substances into groundwater.

4. Clearing the roof of the third power unit from radioactive waste.

5. Construction of the Shelter or Sarcophagus. The main part of the sarcophagus was built by November 1986. The entire facility, a reinforced concrete structure, was completed in 1988. The Shelter reduced radiation from the destroyed reactor by 100 times. The Sarcophagus was built as a control and measuring system

capable of not only monitoring processes in the reactor, but also predicting their development.

600,000 liquidators from all over the Soviet Union were involved in the Chernobyl disaster cleanup efforts. According to the Russian National Radiation and Epidemiological Registry (NRER), radiation sickness was detected in 134 people who were at the damaged unit during the first 24 hours. Of these, 28 died within a few months of the accident (27 in Russia), and 20 died of various causes over the course of 20 years.

Over the past 30 years (up to 2016), 122 cases of leukemia among liquidators have been recorded in the NRER. 37 of them could have been induced by Chernobyl radiation. Between 1986 and 2011, of the 195,000 Russian liquidators registered in the NRER, about 40,000 died from various causes, while the overall mortality rates did not exceed the corresponding average values for the population of the Russian Federation.

8.2. Direction of propagation of the radioactive cloud and the nature of radioactive contamination of territories

After the Chernobyl disaster, radioactive fallout continued for two years. Radioactive contamination of the earth's surface was recorded on two continents – Eurasia and North America.

The Chernobyl disaster covered the territory of two continents:

1. Eastern Europe: Belarus, Russia, Ukraine, Hungary, Poland, Romania, Czech Republic, Bulgaria, Moldova
2. Northern Europe: Sweden, Finland, Norway, Denmark.
3. Western Europe: Belgium, France, Ireland, Netherlands, Luxembourg, Austria, Germany, Switzerland.
4. Southern Europe: Greece, Spain, Portugal, Italy, Slovenia.
5. Western Asia: Cyprus, Israel, Syria, Turkey.
6. East Asia: China, Japan.
7. South Asia: India.
8. North America: Canada, USA.

The nature of radioactive contamination of the territory of the Republic of Belarus. Radioactive contamination of Belarus began immediately after the explosion of the reactor of the 4th power unit of the Chernobyl Nuclear Power Plant, since the radioactive cloud moved in the north-west and north directions. Features of meteorological conditions and the dynamics of the release of radioactive substances determined the mosaic, uneven nature of contamination of the territory of the Republic of Belarus. At present, radioactive contamination has been registered in 5 regions and 49 districts of Belarus (Table 23).

Immediately after the Chernobyl accident, the radiation situation in Belarus was determined by the action of short-lived radionuclides, mainly iodine-131 (^{131}I). Contamination with this radionuclide was observed practically throughout the entire territory of Belarus.

Table 6

Regions of Belarus contaminated with Chernobyl radionuclides

Regions	Number of districts	Areas contaminated with radionuclides
Gomel	21	19
Mogilevskaya	21	13
Minsk	22	10
Brest	16	4
Grodno	17	3

The Bragin, Khoyniki and Narovlya districts of the Gomel region were subject to the highest contamination with ^{131}I. The contamination level of these territories was 37,000 kBq /m^2 (1000 Ci/km$^{2)}$. In the Vetkovsky district of the Gomel region, the content of radioactive iodine in the soil reached 20,000 kBq /m^2. In the Mogilev region, the Cherikov and Krasnopolsky districts were subject to the highest contamination. In the above-mentioned territories, the contamination level with iodine-131 was 5550–11100 kBq / m^2.

The largest contribution to radioactive contamination of the territory of the Republic of Belarus was made by cesium-137. The area contaminated with this radionuclide with a level of more than 37 kBq /m^2 (1 Ci/km^2) was 46.45 thousand km^2 (23% of the total area of the republic). As of January 1, 2015, the area contaminated with ^{137}Cs with the above-mentioned level was 27.89 thousand km^2. In addition, the density of soil contamination with this radionuclide with a level of more than 10 kBq /m^2 (0.27 Ci/km$^{2)}$ was recorded over an area of 136.5 thousand km^2.

In some areas of the 30-kilometer zone, the levels of contamination of the territory with ^{137}Cs exceeded 37,000 kBq /m^{2}E. Even 30 years after the Chernobyl disaster, the levels of contamination of the territory of the above-mentioned zone with cesium-137 exceed 14,800 kBq / m^2.

Also, the highest levels of cesium-137 contamination were observed in the north-eastern part of the Gomel and south-eastern part of the Mogilev regions.

The highest density of soil contamination with plutonium - 238, 239, 240, 241 isotopes with a level of more than 37 kBq/m^2 (1 Ci/km^{2}) was recorded in the Khoyniki and Bragin districts of the Gomel region on the territory of the Polesie State Radiation and Ecological Reserve. On an area of 4 thousand km^{2} (2% of the territory of the republic), the density of soil contamination with plutonium-238, 239, 240 isotopes was over 0.37 kBq / m^2 .

Currently, there are 826 thousand registered citizens in Belarus who have suffered from the Chernobyl disaster and other radiation accidents.

The territory of radioactive contamination includes a part of the territory of the Republic of Belarus with a density of soil contamination with radionuclides of cesium-137 or strontium-90 or plutonium-238, 239, 240 of 37, 5.55, 0.37 kBq /sq. m (1.0, 0.15, 0.01 Ci/sq. km) and more, respectively, as well as other territories in

which the average annual effective dose of radiation to the population may exceed 1 mSv.

In the territory of radioactive contamination, depending on the density of soil contamination with radionuclides and the average annual equivalent dose of radiation to the population, the following **zones of radioactive contamination are distinguished:**

1. Evacuation (exclusion) zone – the territory around the Chernobyl Nuclear Power Plant from which the population was evacuated in 1986 (30-kilometer zone) and the territory from which additional resettlement of the population was carried out due to the density of soil contamination with strontium-90 radionuclides over 111 kBq /m^2 (3 Ci/sq km) and plutonium-238, 239, 240 over 3.7 kBq/m^2 (0.1 Ci/ km^2).

2. The priority resettlement zone is an area with a soil contamination density of cesium-137 radionuclides of 1480 kBq / m^2 (40 Ci/sq. km) or strontium-90 or plutonium-238, 239, 240, respectively 111, 3.7 kBq /sq. m (3, 0.1 Ci/km^2) and more.

3. The zone of subsequent resettlement is an area with a density of soil contamination with cesium-137 radionuclides from 555 to 1480 kBq /m2 (15 to 40 Ci/km2) or strontium-90 from 74 to 111 kBq /m2 (2 to 3 Ci/km2) or plutonium-238, 239, 240 from 1.85 to 3.7 kBq /m^2 (0.05 to 0.1 Ci/km^2), in which the average annual effective radiation dose to the population may exceed 5 mSv , and other areas with a lower density of contamination with the specified radionuclides, in which the average annual effective radiation dose to the population may exceed 5 mSv .

4. Zone with the right to resettlement - an area with a soil contamination density of cesium-137 radionuclides from 185 to 555 kBq / sq. m (from 5 to 15 Ci / sq. km) or strontium-90 from 18.5 to 74 kBq / sq. m (from 0.5 to 2 Ci / sq. km) or plutonium-238, 239, 240 from 0.74 to 1.85 kBq / sq. m (from 0.02 to 0.05 Ci / sq. km), in which the average annual effective radiation dose to the population may exceed 1 mSv , and other areas with a lower contamination density of the specified radionuclides, in which the average annual effective radiation dose to the population may exceed 1 mSv .

5. Residential zone with periodic radiation monitoring – territory with a soil contamination density of cesium-137 radionuclides from 37 to 185 kBq /m^2 (1 to 5 Ci/km^2) or strontium-90 from 5.55 to 18.5 kBq /m^2 (0.15 to 0.5 Ci/km^2) or plutonium-238, 239, 240 from 0.37 to 0.74 kBq /m^2 (0.01 to 0.02 Ci/km^2), in which the average annual effective radiation dose to the population should not exceed 1 mSv.

In accordance with the Resolution of the Council of Ministers of the Republic of Belarus dated January 11, 2016 “On approval of the list of settlements and objects located in radioactive contamination zones” The regions of Belarus that are located in areas of radioactive contamination have been identified (Table 6).

Table 6

Regions of the Republic of Belarus located in zones of radioactive contamination

Region	Radioactive contamination zone
Gomel	Residential area with periodic radiation monitoring
	Zone with the right of resettlement
	Subsequent resettlement zone
Mogilevskaya	Residential area with periodic radiation monitoring
	Zone with the right of resettlement
	Subsequent resettlement zone
Minsk	Residential area with periodic radiation monitoring
	Zone with the right of resettlement
Brest	Residential area with periodic radiation monitoring
	Zone with the right of resettlement
Grodno	Residential area with periodic radiation monitoring

By the Resolution of the Supreme Council of the BSSR of July 19, 1990 "On measures to accelerate the implementation of the State Program for the Elimination of the Consequences of the Disaster at the Chernobyl Nuclear Power Plant," the Republic of Belarus was declared **a zone of national ecological disaster.**

8.3. Pathways of external and internal irradiation of the population living in the radioactive contamination zone. Half-life and brief characteristics of the main radionuclides

After the Chernobyl disaster, several types of exposure to radioactive substances on the human body were formed:

1. External gamma irradiation from a radioactive cloud. The contribution of this irradiation to the formation of the dose was 2.5%. External gamma irradiation was short-term and continued until a radioactive trace was formed on the ground.

2. Inhalation of radioactive substances into the human body. Associated with internal irradiation of the body and makes up 4.5% of the dose of this radiation. Inhalation irradiation is caused by aerosol air pollution and develops in 2 stages:

a) relatively short-term. This type is characterized by the release of various gases and aerosols from the reactor, the formation and movement of radioactive clouds, and their deposition on the surface of the earth and water;

b) continuous – secondary pollution of the atmosphere caused by the wind-blown dust. Secondary pollution of the atmosphere is particularly dangerous for the population permanently living and working in radioactively contaminated areas.

3. External gamma radiation from radionuclides deposited on the earth's surface. The impact of deposited radionuclides on the human body is very intense and long-lasting. Its contribution to the external irradiation dose of the population is 50–60%.

4. Radionuclides entering the human body through food chains. This type of radionuclide exposure is characterized by the characteristics of soils, mainly in the Belarusian Polesie. More than half of the radioactively contaminated lands of Belarus are soils of light mechanical composition. Light soils are characterized by the following properties: insignificant absorption capacity, low humus content and secondary clay materials. In these soils, radionuclides such as cesium-137 and strontium-90 are poorly bound by soil particles, and therefore the coefficient of their transfer to plants is high. Light soils (sandy, podzolic, peat-bog) are typical of the Belarusian Polesie. Unlike light soils, chernozem and clay soil bind radionuclides well.

Half-life and brief characteristics of the main radionuclides. Iodine-131 is a source of beta (β) and gamma (γ) radiation. Half-life ($T_{1/2}$) is more than 8 days. ^{131}I has high volatility and penetrates well into milk, fish, vegetables and berries. It enters the human body through the respiratory system, gastrointestinal tract and skin. Iodine-131 mainly enters the thyroid gland, where its concentration is 200 times higher than in other organs and tissues. The accumulation of radioactive iodine in the human thyroid gland leads to a disruption in the formation of hormones in it and changes in the processes of growth, maturation of tissues and organs, and the processes of growth and development of bones. ^{131}I damages the genetic apparatus of thyroid cells and contributes to the development of cancer in it. The biological half-life (T_{biol}) of radioactive iodine from the thyroid gland is 138 days, from other organs - 10-15 days.

Due to the fact that iodine prophylaxis was not carried out immediately in the BSSR, a significant part of the population was exposed to high levels of thyroid gland irradiation. Iodine prophylaxis was carried out only from May 2 for migrants from the affected areas; iodine prophylaxis was not carried out for the rest of the population.

Cesium-137 is an alkali metal that produces β- and γ-radiation. $T_{1/2}$ – over 30 years. Before the Chernobyl accident, cesium was released into the environment due to nuclear explosions. Cesium-137 is very volatile, which explains the contamination of large areas of the USSR and the world as a whole. Large amounts of ^{137}Cs are concentrated in grain, potato stems, greens, and fish. The main route of entry into the human body is the gastrointestinal tract. Most of the radioactive cesium is well absorbed by the body. This radionuclide mainly accumulates in the muscles,

heart, and liver. Cesium-137 is an analogue of potassium (with a low potassium content in the body, cesium is absorbed). As a result of irradiation of the body with ^{137}Cs, the following occurs: suppression of the hematopoietic system, leukemia, breast cancer, liver cancer, skin tumors, etc. $T_{biol.}$ from the body of adults is 80–160 days, and from the body of children – 40–80 days.

Strontium-90 is an alkaline earth metal that is well absorbed by plants, animals, and humans. It is a source of beta radiation. The half-life of this microelement is over 29 years. Strontium-90 is not highly volatile, and the areas contaminated with it are insignificant. It enters the human body through the food chain (plant–animal–human). The main concentrators of ^{90} Sr are: cereals, leafy vegetables, fish, whole milk, bone broths. ^{90} Sr is an analogue of calcium in its chemical properties, so it accumulates mainly in bone tissue. Concentrating in bones, this radionuclide irradiates the red bone marrow, which contributes to the development of blood cancer in humans and animals. The half-life of strontium-90 from soft tissues is 10 days, from bones – 8–10 years.

Plutonium-239 is a metal belonging to the radioactive series of actinium (uranium-actinium) and rare earth metals. This radionuclide is characterized by α-radiation and weak γ-radiation. $T_{1/2}$ of plutonium-239 is more than 24,000 years. It enters the human body through the lungs and gastrointestinal tract. With a lack of strontium and calcium, ^{239} Pu is concentrated in bone tissue. This microelement also accumulates in the lungs, liver, and lymph nodes. Plutonium-239 suppresses the hematopoietic system, the immune system, leads to the formation of liver cirrhosis, lung and bone tumors. T_{biol} from bone tissue is 100 years, from the liver - 40 years. For the chronology of events at the Chernobyl station and the consequences, see the video (Fig. 35).

8.4. Assessment of economic damage caused to the country by the Chernobyl disaster

The economic damage caused to the Republic of Belarus as a result of the Chernobyl disaster is estimated at 235 billion US dollars (32 state budgets of the republic for 1985). These economic losses of Belarus are calculated for a 30-year period of overcoming the consequences of the Chernobyl disaster. As a result of significant pollution of the Republic of Belarus, the following were liquidated in the resettlement territory: 53 agricultural organizations, 95 hospitals, 607 schools and kindergartens, more than 500 consumer services, trade and public catering facilities, more than 430 settlements.

Fig.35. Modern object shelter 2 in 2017-18 x (Video 3 min 33 sec) https://www.youtube.com/watch?v=v_0w2g0bw_8

265.4 thousand hectares of land were withdrawn from agricultural use. Despite the significant spread of radionuclides in the Republic of Belarus, about 340 industrial enterprises operated in radioactively contaminated zones (Table 7).

Some enterprises have suffered major losses due to the reduction in production volumes due to the resettlement of residents from contaminated areas. The main losses are in fuel and raw materials.

The area of agricultural lands in Belarus contaminated with cesium-137 is 1.8 million hectares (about 20% of their total area). The territory of forest resources in zones of radioactive contamination is 1.5 million hectares, or 18.6% of the total area of forest resources in Belarus.

Table 7

Industry of Belarus in radioactive contamination zones

Industry	Production (%)
Mining metallurgy	73
Medical and microbiological	43
Fuel	40
Forestry, woodworking, pulp and paper	35

There are 57 mineral resource deposits in the territory contaminated with radionuclides. As a result of radioactive contamination in the southern part of the Pripyat oil and gas deposit (25.3 million tons of oil), geological exploration work has been limited.

Control questionss

1. What are the main causes of the accident at the fourth power unit of the Chernobyl nuclear power plant?
2. Describe the stages of development of the Chernobyl disaster.
3. Describe the measures taken to eliminate the accident at the Chernobyl nuclear power plant.
4. Name the countries that were exposed to radioactive contamination after the disaster at the fourth power unit of the Chernobyl nuclear power plant.
5. Indicate the regions and districts of Belarus contaminated with radionuclides as a result of the Chernobyl disaster.
6. What zones of radioactive contamination were identified on the territory of Belarus after the accident at the Chernobyl nuclear power plant?
7. Name the types of effects of radioactive substances on the human body.
8. Describe the main radioactive elements.
9. Describe the extent of economic damage caused to agriculture and forestry in Belarus by the Chernobyl disaster.
10. Describe the scale of economic damage caused by the accident at the Chernobyl nuclear power plant to industrial and social facilities in the Republic of Belarus.

Lecture 9. Biological effects of ionizing radiation on the human body

Lecture plan:

9.1. The effect of various types of ionizing radiation on the body.

9.2. Sensitivity of organs and tissues to the effects of ionizing radiation.

9.3. Threshold level of radiation dose. Deterministic and stochastic effects of exposure to ionizing radiation on the body.

9.1 The effect of various types of ionizing radiation on the body

The effect of ionizing radiation on the human body is determined by the structure of the atom, the nucleus and the physical processes occurring in them.

Living bodies consist from chemical substances, as well as inanimate bodies nature. The most important component of these substances are chemical elements. The smallest particles of chemical elements are atoms. In the center of the atom is the nucleus, consisting of protons and neutrons. Outside the nucleus, electrons are located in orbitals.

In nature, there are chemical elements whose atoms consist of different numbers of neutrons, but the same number of protons. Such atoms are called isotopes. Isotopes have a mass number (A) and a charge number (Z). The mass number includes protons and neutrons. The charge number (atomic number, ordinal number of a chemical element) consists of protons. The number of neutrons is equal to the difference between the mass and charge numbers: $N = A – Z$.

Most elements in the periodic table have several isotopes. Currently, 108 chemical elements contain 1900 isotopes. Of the natural isotopes, approximately 280 are stable, 46 are radioactive. The remaining isotopes were obtained artificially as a result of nuclear reactions.

Along with isotopes or radioisotopes, there are also different chemical elements. Such elements are called nuclides (radionuclides).

Radioactivity is the property of atomic nuclei of some chemical elements to spontaneously transform (decay) into other elements with the emission of various types of radiation. The cause of nuclear decay is a violation of the ratio between the number of protons and neutrons. Such violations are characteristic of both heavy and light chemical elements.

The spread of various types of radiation associated with the transformation of atomic nuclei is called **radiation.**

Radioactivity and radiation existed in space even before the Earth appeared. Radioactive elements were part of the Earth even before life began on it. Mutations caused by radioactivity may have been one of the main reasons for the increase in the organization of living organisms during their evolution. Any living tissue, including the human body, contains trace amounts of radioactive substances.

Radioactive radiation that forms charged ions when interacting with the environment is called **ionizing.** There are two types of ionizing radiation - corpuscular and electromagnetic.

Corpuscular radiation consists of particles: β-particles (electrons and positrons), α-particles (protons and neutrons). **Electromagnetic radiation** is represented by quanta or photons (γ-radiation, X-ray radiation). Electromagnetic and corpuscular radiation are characterized by a number of parameters such as energy, speed, free path, ionizing ability (Table 8).

The parameters of radiation determine the nature of the impact on the human body. As the length of the radiation path increases, its penetrating ability also increases.

Thus, *α-radiation with low penetrating* ability is completely retained by human skin. The following can serve as protection from alpha particles: clothing, a sheet of paper, a 10-centimeter layer of air.

Beta radiation, due to *its greater penetrating ability*, causes the formation of various burns on the exposed surface of the skin. In addition, the effect of these radiations on the lens of the eye can lead to radiation cataracts. Winter clothing, glass, and aluminum protect against β-particles.

Among the above-mentioned radiations, *gamma rays have the greatest penetrating ability*. Gamma quanta pass through the human body. Lead and concrete are used to protect against gamma radiation. Lead 1.6 cm thick and concrete 10 cm thick can reduce the impact of gamma quanta, such as radioactive cobalt, by 2 times.

Table 8

Parameters of the main ionizing radiations

Type of radiation	Parameters			
	Energy	Speed (km/s)	Length of run	Ionizing capacity
α	2–11 MeV	12000–22500	in the air – 2–10 cm, in a biological environment (water, tissue) – 0.1 mm	25–100 thousand ion pairs
β	0.015–13.5 MeV	100-300 thousand	air – 25 cm–20 m, water and biological tissue – up to 2 cm	20–300 ion pairs
γ	10 keV–5 MeV	300 thousand	In the air 100 m–1.5 km, in tissues – 14 cm–1 m	2-3 pairs Ionov

Along with the penetrating effect, the ionizing ability is also of great importance. The greater the ionization, the greater the destructive effect of radiation on the human body.

The process of human irradiation is closely related to ionizing radiation. **Irradiation** is the effect of ionizing radiation on objects of the environment (plants, animals, humans). It is divided into external and internal.

External irradiation is the irradiation of tissues of living organisms with ionizing radiation coming from outside.

Internal radiation is radiation from radioactive substances located inside the body.

The external radiation dose is distributed as follows: 14% – dose of gamma radiation from the Earth and buildings, 12% – food and drinks, 10% – cosmic rays. In addition, the population of Belarus is additionally exposed to radiation from radionuclides: cesium-137 (90%), strontium-90 (9%), plutonium isotopes (1%).

Internal irradiation occurs when radioactive substances enter the body with food, air and water. It is formed by artificial radiation (cesium, strontium, plutonium) and radiation of natural origin. The latter accounts for 67% of the total radiation dose.

There are stages of exposure of the human body to ionizing radiation.

1. Physical stage. Characterized by ionization and excitation of atoms and molecules as a result of absorption of ionizing radiation energy. The duration of the physical stage is 10^{-12}–10^{-8} s.

2. Physicochemical stage. The rupture of chemical bonds of cell and tissue molecules is observed under the influence of ionizing radiation energy and water radiolysis (decay) products. These changes can lead to the destruction of proteins, enzymes, hormones. The duration of the physicochemical stage is from 10^{-7} s to several hours.

3. Molecular biological stage. At this stage, the following changes occur: damage to cell membranes, cell organelles, disruption of RNA and DNA synthesis, presence of gene mutations. Disruption of RNA synthesis contributes to the formation of malignant tumors and secondary radiotoxins that cause radiation sickness and aging. At the molecular biological stage, damage to enzyme macromolecules and various changes in proteins, lipids and carbohydrates are also observed.

4. The stage of biological effects is characterized by damage to various organs and systems: red bone marrow, gastrointestinal tract. Malignant neoplasms are noted: thyroid gland, lungs, blood, etc. Changes in genetic characteristics are observed as a result of mutations.

9.2. Sensitivity of organs and tissues to the effects of ionizing radiation

Changes occurring in the organism of plants, animals and humans under the influence of radioactive radiation are determined by such indicators as radiosensitivity and radioresistance (radiostability).

Radiosensitivity is the response of tissues, organs and body systems to low levels of ionizing radiation.

Radioresistance (radiostability) is the body's resistance to high doses of radiation.

These indicators are influenced by a number of factors:

1. Radiation dose. Changes in the human body can be caused by both single and multiple irradiation. A single dose of radiation is the dose received by a person during the first four days. The maximum permissible dose of a single dose is 0.5 Sv.

A dose of radiation exceeding four days is called multiple. With multiple irradiation (10–30 days), the maximum permissible dose is 1Sv (the onset of acute radiation sickness).

2. Irradiation time. Within two months, the irradiated organism is restored by 85%. Irreversible changes in the human organism associated with exposure to ionizing radiation are 15%. Thus, a dose of 0.5Sv can be received again after 2 months. In this case, the total dose should not exceed 1Sv.

3. Type of radiation. The main parameter characterizing the impact of radiation on the human body is ionization. Alpha radiation has the greatest ionizing ability. When entering the body, alpha particles are 20 times more dangerous than gamma quanta.

4. Age. It has been established that children and the elderly are more susceptible to the effects of ionizing radiation. The body's susceptibility to radiation is associated with age-related changes in the immune system. In childhood, the immune system is not yet formed. In old age, it is already weakened.

5. Functional state of the body. Chronic diseases, blood loss, burns, pregnancy (8-15 weeks) increase the impact of radiation on the human body.

6. Individual characteristics of the organism. The sensitivity of different people to the effects of ionizing radiation is not the same. For example, the liquidators who received the same doses had different degrees of radiation damage.

7. Gender-specific radiosensitivity of the body. It has been established that men are less resistant to the effects of ionizing radiation than women.

8. Accumulation of radionuclides in the body. For example, iodine-131 is concentrated in the thyroid gland. Accumulation of strontium-90 occurs in bone tissue. Organs that concentrate radionuclides are subject to high doses of internal radiation and various diseases. In this case, radiation can spread to other tissues and organs.

9. Sensitivity of organs and tissues to the effects of ionizing radiation. Different human organs and tissues have different sensitivities to the effects of ionizing radiation. Radiosensitivity at the level of organs and tissues is mainly determined by the features of cell functioning. Tissues consisting of poorly differentiated, actively proliferating cells are the most sensitive to the effects of ionizing radiation. Highly specialized, poorly renewed tissues are more resistant to radiation. Lymphocytes are an exception. These cells are highly specialized and are characterized by high radiosensitivity.

According to the degree of decrease in sensitivity to the effects of ionizing radiation, tissues and organs can be placed in the following order: red bone marrow and lymphoid tissue, sex glands, skin, lungs, digestive glands, thyroid gland, muscle tissue, bone tissue, nervous tissue (fig. 36).

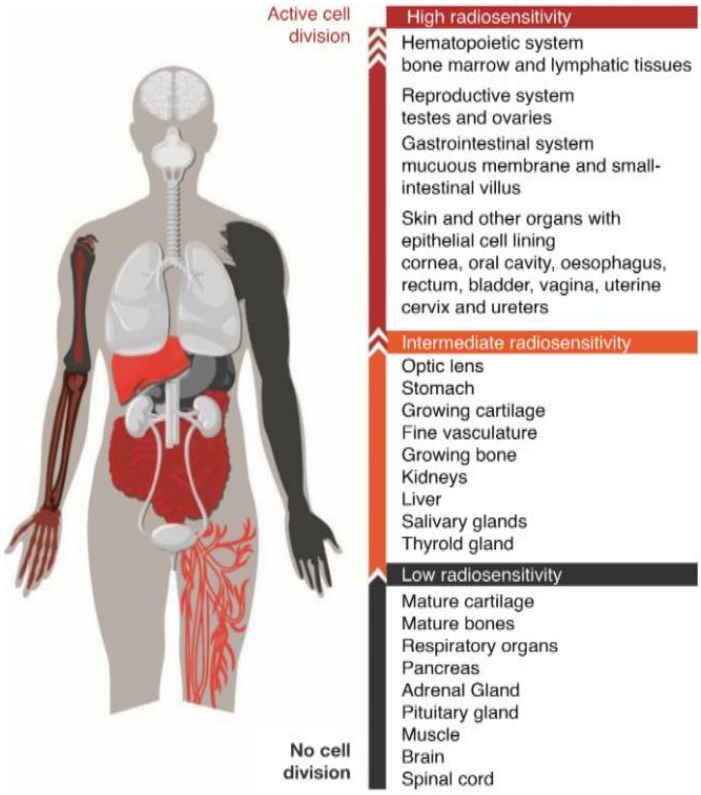


Fig. 36. Radiosensitivity of organs and tissues to the effects of radiation.

9.2 Threshold level of radiation dose. Deterministic and stochastic effects of exposure to ionizing radiation on the body

The threshold level of radiation dose is a safe dose of radiation that does not have a damaging effect on the human body. Taking this indicator into account, threshold and non-threshold effects of radiation are distinguished. The threshold effect of radiation includes **deterministic** radiobiological effects (tissue reactions), and the non-threshold effect includes stochastic (**probabilistic)** effects of ionizing radiation.

Deterministic effects of radiation in humans occur when there is a single threshold dose of **0.25Sv.** This value is not strict and depends mainly on the individual characteristics of the organism.

Deterministic radiobiological effects are divided into ***immediate*** (occurring within a few weeks after irradiation) and ***remote*** (occurring several years after irradiation). Immediate effects of radiation include: acute and chronic radiation sickness, local radiation damage (radiation burns of the skin, radiation cataracts, sterilization). After the Chernobyl disaster, a specific form of ARS was detected in the human body. This form was associated with the effect on the body of general, relatively uniform gamma irradiation of the entire body in combination with beta irradiation of the skin and partial intake of a mixture of radionuclides (iodine, cesium) through the respiratory system.

The main victims of the Chernobyl disaster were the employees of the nuclear power plant and the participants in the liquidation of the consequences of the accident at the Chernobyl Nuclear Power Plant. Of the 237 victims, 134 were diagnosed with acute radiation sickness. Victims with this diagnosis had varying degrees of severity of this disease.

Remote effects of radiation include: radiosclerotic processes, radiocataractogenesis, radiocarcinogenesis.

Stochastic (probabilistic) effects of ionizing radiation do not have a dose threshold, and the severity of their manifestation does not depend on the dose. At the same time, with an increase in dose, the risk of these effects increases.

Stochastic effects of radiation include: ***somatic-stochastic*** (malignant neoplasms), ***genetic*** (gene mutations and chromosomal aberrations), ***teratogenic*** (delayed physical and mental development; risk of cancer).

In an irradiated person, the latent (hidden) period of occurrence of stochastic effects of ionizing radiation ranges from 2–5 to 30–50 years or more.

Psychological problems associated with the real or subjectively perceived danger of radiation exposure

Psychological problems that people experience in connection with the danger of radiation exposure are caused by various psychological reactions.

There are several stages of psychological reactions to radiation:

1. Acute stress reaction. At this stage, various emotional reactions occur. These reactions are divided into immediate and subsequent. Immediate emotional reactions are observed already during the radiation catastrophe itself. Immediately after the end of the catastrophe and much later, subsequent emotional reactions occur.

2. Post-traumatic stress disorder (PTSD) is characterized by various changes in the body. The following criterion groups of the main symptoms of PTSD are distinguished:

- obsessive experiences (illusions, delusions, nightmares);
- development of detachment, alienation from real life;
- high level of emotional stress.

The above symptoms are observed in the human body for several weeks and even months. It usually takes many years for a person to fully recover from PTSD on their own.

3. Regulation disorder. At this stage, there is gradual restoration of the psychological status of the human body. Despite this, various regulatory disorders can be observed in the human body over many years. These disorders are associated with both the neuropsychic activity of a person and the function of various body systems.

Control questions

1. Formulate the definition of the concepts "Radioactivity", "Radiation".
2. What is ionizing radiation?
3. Describe the features of penetrating and ionizing ability of various types of radiation.
4. What do the terms "Irradiation", "External Irradiation", "Internal Irradiation" mean?
5. Describe the stages of exposure to ionizing radiation on the human body.
6. Describe the features of accumulation of radioactive substances in the human body.
7. What is the radiosensitivity of organs and tissues to the effects of ionizing radiation?
8. Describe deterministic radiobiological effects.
9. Describe the stochastic effects of radiation.
10. Describe the psychological problems associated with the perceived danger of radiation exposure.

Lecture 10. Basic measures to protect the population from radiation exposure during accidents at nuclear power plants

Lecture plan:

10.1. Legislation of the Republic of Belarus in the field of radiation safety.
10.2. Classification of measures to protect the population from man-made radiation as a result of accidents at nuclear power plants.
10.3. Food Radiation Monitoring and Control System

10.1. Legislation of the Republic of Belarus in the field of radiation safety

In accordance with the Law of the Republic of Belarus of January 5, 1998 "On the radiation safety of the population", principles of ensuring the radiation safety of the population in the event of a radiation accident and principles of ensuring radiation safety in practical activities are distinguished.

Radiation safety of the population during a radiation accident is ensured by the following principles:

- intervention levels should ensure the prevention of early and limitation of late medical consequences of radiation;
- the proposed measures to eliminate the consequences of a radiation accident must bring more benefit than harm;
- The types and scale of activities to eliminate the consequences of a radiation accident must be implemented in such a way that the benefit from reducing the dose of ionizing radiation, with the exception of the harm caused by the said activity, is maximal.

Ensuring radiation safety in practical activities includes the following principles:

- the principle of standardization is not to exceed the permissible limits of individual radiation doses for citizens from all sources of ionizing radiation;
- the principle of justification – prohibition of all types of activities involving the use of sources of ionizing radiation, in which the benefit received by humans and society does not exceed the risk of possible harm caused by exposure to radiation that exceeds the natural background radiation;
- the principle of optimization is to maintain individual radiation doses and the number of irradiated persons at an achievably low level, taking into account economic and social factors, when using any source of ionizing radiation.

10.2. Classification of measures to protect the population from man-made radiation as a result of accidents at nuclear power plants

The classification of measures to protect the population from radiation was developed in accordance with the Resolution of the Ministry of Health of the Republic of Belarus dated 28.12.2012 "On approval of Sanitary norms and rules "Radiation safety requirements".

Urgent protective measure – a protective measure in the event of an emergency that, in order to be effective, must be carried out promptly (usually within a few hours) and the effectiveness of which will be significantly reduced if it is delayed.

Urgent protective measures include: evacuation, decontamination of people, sheltering, respiratory protection, thyroid blocking, and restrictions on the consumption of potentially contaminated foods.

Long-term measures include: resettlement, agricultural countermeasures, and restoration measures.

Evacuation and resettlement. In April-May 1986, measures to protect the population and eliminate the consequences of the Chernobyl accident were carried out under the leadership of the Council of Ministers of the USSR and the Ministry of Health of the USSR. The most important measures to protect the population were evacuation and resettlement.

Evacuation is an urgent, temporary movement (removal) of people from a territory in order to prevent or reduce short-term radiation exposure in the event of an emergency.

Resettlement (resettlement) is a non-emergency removal or mass movement of people from a contaminated territory (zone) in order to prevent chronic exposure.

A distinction is made between ***permanent resettlement*** (the duration exceeds one or two years and return is not envisaged) and ***temporary resettlement***.

Following the disaster at Unit 4 of the Chernobyl NPP, the evacuation of the population of Belarus was carried out taking into account the assessment of the exposure dose of radiation. Initially, the evacuation was carried out within a 10-km radius of the Chernobyl NPP. In this territory, the radiation dose reached 25 mR /h.

Subsequently, evacuation was carried out in a 30-km zone from the Chernobyl NPP. The exposure dose of radiation in this zone was 5 mR /h. The 30-km zone of the Chernobyl disaster covered 3 districts of the Republic of Belarus - Bragin, Khoiniki, Narovlya. Evacuation in these territories began on May 2, 1986. Within three days, 50 villages with a population of 11,035 people were evacuated. From June 2 to 9, an additional resettlement of 28 villages (6,017 people) was carried out. Another 29 villages (7,327 people) were additionally resettled at the end of August.

During 1986, 24.7 thousand residents were evacuated and resettled from 107 of the most contaminated settlements in Belarus.

Subsequently, measures were taken to resettle people from the priority and subsequent resettlement zones. These measures were completed in 2007. **Over a period of more than 20 years, 137.7 thousand people were evacuated and resettled from the most contaminated settlements of the Republic of Belarus.** In addition, 200 thousand people left the radioactively contaminated territories on their own.

Decontamination of people. The most important measure for decontamination of people is **sanitary treatment**. The main methods of this measure are: the use of insulating films and biological protection.

Insulating films are designed to prevent contamination of the skin of exposed areas of the body and to remove radionuclides from the skin surface. Various pastes, ointments, and special creams are used as insulating films. If various plutonium compounds come into contact with the skin, 96% clay pastes with various additives can be used Kaolin (white clay) is used to protect against other radioactive substances. Laundry soap and soda ash are used as additives to this product. Despite the protective properties of insulating films, they do not exclude the irradiation of people with beta particles and gamma quanta. Bioprotection is used to reduce this irradiation.

There are two types of biological protection - individual and group. **Individual protection** is characterized by the use of clothing with lead plates (half helmets, aprons, swimming trunks, shoe covers, etc.). **Group biological protection** is represented by technical systems consisting of shielded equipment cabins. It has been established that insulating films do not guarantee complete protection of the skin from exposure to radioactive substances.

In addition to the use of insulating films and bioprotection, there are other methods of sanitizing people. The simplest method of decontaminating the skin is to use warm water with soap. If the sebaceous glands secrete fat intensively, the skin can be treated with alcohol or ether. If the nose and ears are contaminated with radioactive dust, they are washed with water.

Thyroid blocking. The main method of protecting the thyroid gland from radioactive iodine-131 is **iodine prophylaxis**. This method is characterized by saturating the thyroid gland with drugs containing stable iodine (Table 9).

Table 9

Use of potassium iodide in radiation injuries

Age group	Dose	Frequency and duration of use
Adults and children from 14 years old	tablet 0.125 g	Every day for 7 days
Children from 3 to 14 years old	tablet 0.065 g	Every day for 7 days
Children under 3 years old	tablet 0.065 g	Every day for 2 days
Pregnant and breastfeeding women	tablet 0.125 g	Every day for 2 days

Iodine-containing drugs include: potassium iodide, 5% solution of iodine tincture (Table 10).

Table 10

Use of 5% iodine tincture in accidents at nuclear power plants

Directions for use	Age group	Dose	Frequency and duration of use
Internal	Adults and children from 14 years old	44 drops or 22 drops	1 time per day for 7 days
	Children from 5 to 14 years old	22 drops	1 time per day for 7 days
	Children under 5 years old	Not assigned	
External	Adults and children from 14 years old	44 drops each	1 time per day for 7 days
	Children from 2 to 14 years old	22 drops	1 time per day for 7 days
	Children under 2 years old	11 drops	1 time per day for 7 days

For external use, iodine tincture is poured into the palm of the hand and then applied to the forearm or shin.

Usually, a 5% solution of iodine tincture is used in the absence of potassium iodide tablets.

Respiratory protection. To protect the respiratory system from radioactive contamination, it is necessary to use various personal protective equipment: gas masks, respirators, cotton-gauze bandages, anti-dust fabric masks.

Shelter. One of the most important ways to protect the population from the effects of ionizing radiation is temporary shelter in houses and shelters. The protective properties of various objects are determined by the radiation dose attenuation coefficient (Table 11).

Table 11

Radiation attenuation coefficient of various objects

Object	Attenuation coefficient
Wooden houses Basements	2–13 7–16
Brick houses Basements	10–75 37–600
Fallout shelters	100–500
Shelters	1350–9100

In addition to the protective properties of the object, sealing the premises (tightly closing doors, windows, chimneys and ventilation openings) helps reduce radiation.

Countermeasures in agriculture. After the Chernobyl disaster, lands in the intensive agricultural zone in Belarus were contaminated. As of January 2022, due to natural decay, the area of land contaminated with radionuclides has decreased, and agriculture is carried out on an area of 836.6 thousand hectares of land with a cesium-137 contamination density of more than 37 kBq / m^2 (more than 1 Ci / km^2), of which 281.5 thousand hectares are simultaneously contaminated with strontium-90 more than 5.55 kBq /m^2 (more than 0.15 Ci / km^2). This area includes 59 districts of the Republic of Belarus (Table 12).

Table 12

Distribution of agricultural land contaminated with cesium-137 by regions of Belarus in 2022

Region	Pollution of agricultural lands, %
Gomel	59.9
Mogilevskaya	29.8
Brest	4.3
Minsk	4.4
Grodno	1.6

Contamination of soils with strontium-90 was recorded simultaneously with cesium-137 on an area of 348.2 thousand hectares. The entry of strontium-90 from

soil into plants is 10 times higher than that of cesium-137 with the same contamination density. The peculiarities of entry of strontium-90 into plants are due to its high mobility.

Unlike strontium-90, cesium-137 is more rapidly transferred from feed to meat and dairy products.

In 50–70% of cases, the human radiation dose occurs due to the intake of radioactive substances into the body with food.

There are two stages in the implementation of protective measures in agriculture:

Stage 1 – 1986–1992.

Stage 2 – from 1992 to the present.

At the initial stage, measures were taken to remove agricultural lands with high levels of radioactive contamination from use. Legumes such as peas, clover, lupine, and alfalfa were excluded from crop rotation. These crops are characterized by high levels of strontium-90. In addition, phosphorus-potassium fertilizers were applied in high doses to contaminated areas, and liming of acidic soils was carried out.

The second stage is characterized by the continuation of various agrochemical and agrotechnical measures. At this stage, the following were developed:

- Republican permissible levels of cesium and strontium in food products and drinking water (RDU-99);
- Republican permissible levels of cesium-137 and strontium-90 in agricultural raw materials and feed;
- recommendations for conducting agricultural production in conditions of radioactive contamination of lands in the Republic of Belarus;
- a number of recommendations for obtaining plant products with low levels of radionuclides.

Recovery measures. Activities carried out to restore the affected regions of Belarus include:

1. Construction of various facilities (housing and public utilities, education, healthcare).
2. Gasification.
3. Providing contaminated areas with clean drinking water.

Recommendations for limiting the consumption of potentially radionuclide-contaminated food products. When consuming radioactively contaminated food products, it is necessary to take into account their ability to accumulate radioactive substances. The most important factors determining the concentration of radionuclides in plants are the biological characteristics of the root system. Plants with a shallow root system are characterized by the greatest accumulation of radionuclides. It has been established that about 95% of all radioactive substances contained in the soil are in its 5-centimeter layer. Migration of radioactive substances into the underlying soil layers is very slow.

Concentrating in plants, radionuclides subsequently enter the body of animals and humans. In order to reduce the intake of radioactive substances into the body, it

is necessary to pay attention to the following food products: vegetables, fruits, berries, mushrooms, meat, fish.

Vegetable crops. Vegetables are characterized by the accumulation of cesium-137. According to the degree of reduction of ^{137}Cs content, vegetable crops can be distributed in the following sequence: sweet pepper, cabbage, potatoes, beets, sorrel, radishes, onions, garlic, carrots, cucumbers, tomatoes.

Berries. Berries that accumulate radionuclides more intensively include: blueberries, lingonberries, black currants, cranberries. Berries that accumulate radionuclides less intensively include strawberries, gooseberries, raspberries, and rowanberries.

Mushrooms. According to the accumulation of radionuclides, there are 4 groups of mushrooms:

1) Accumulator mushrooms: Polish mushroom, yellow-brown boletus, saffron milk cap, autumn butter mushroom.

2) Mushrooms that heavily accumulate radionuclides: milk mushroom, black milk mushroom, yellow chanterelle, birch bolete.

3) Mushrooms that accumulate radionuclides moderately: boletus, aspen mushroom, common russula, autumn honey mushroom.

4) Mushrooms with the lowest accumulation of radionuclides (discriminators): champignon, winter honey fungus, common morel, whole and brown russula.

The most important factor in the accumulation of radionuclides in mushrooms is the density of soil contamination with radionuclides in the places of harvesting. Therefore, with a soil contamination density of more than 15 Ci/km2, ^{even} in discriminator mushrooms, the content of radionuclides exceeding permissible levels is noted.

Fruits. This type of plant product is characterized by a slight accumulation of radioactive substances. There are cases of surface contamination of the fruit when harvesting fruits (especially damaged ones) on contaminated soil. Reducing the surface contamination of fruits is facilitated by reducing their contact with the soil and thoroughly cleaning them from soil before storing.

Meat. When assessing the content of radioactive substances in livestock products, the following factors are taken into account: type of product, age of animals, chemical composition of radionuclides and their distribution in tissues and organs. High levels of radioactive substances are typical for poultry, beef and lamb. Cesium is concentrated in significant quantities in the meat of old animals. Accumulation of strontium is noted in the bones of young animals. The highest content of radionuclides in the body of animals is found in the lungs, kidneys and liver.

Radionuclides also accumulate in significant quantities in the meat of wild animals. The largest amount of radionuclides is concentrated in wild boar and hare.

Fish. The main contribution to radioactive contamination of fish is made by cesium-137. Contamination with this radionuclide depends on the habitat of the fish. Fish living in rivers concentrate an insignificant amount of radionuclides. This is explained by the fact that the efficiency of the dilution process of radionuclides in

rivers is very high. The most contaminated are predatory and bottom fish: pike, perch, carp, crucian carp, catfish.

10.3. Food Radiation Monitoring and Control System

Radiation monitoring is a system of regular observations for the purpose of analyzing and forecasting the radiation situation. Radiation monitoring is part of the National Environmental Monitoring System of the Republic of Belarus.

The objects of radiation monitoring are atmospheric air, underground and surface waters, and soil. Monitoring of the radiation situation in Belarus is carried out according to the territorial-production principle. Monitoring units are created by various departmental structures.

Tasks of departmental structures. ***The Ministry of Natural Resources and Environmental Protection*** conducts an assessment of the radiation situation in the territories of populated areas exposed to radiation after the Chernobyl disaster.

The Ministry of Agriculture and Food exercises control over:

- radioactive contamination of agricultural lands owned by farms and gardening associations;
- radioactive contamination of water used by processing plants from their own wells and water used for animal watering;
- the content of radionuclides in agricultural raw materials and products produced in agricultural organizations and purchased from farms.

At markets, analysis of the content of radioactive substances is carried out by veterinary and sanitary laboratories.

The Ministry of Forestry is monitoring radioactive contamination of forest resources and forest products in areas affected by Chernobyl radionuclide fallout.

The Ministry of Housing and Public Utilities is conducting an analysis:

- radionuclide content in drinking water;
- the content of radionuclides in wastewater and its sediments at sewage treatment plants;
- radioactive contamination of municipal waste.

The Ministry of Health monitors radioactive contamination of food products produced in the public sector and private farms.

The Belarusian Republican Union of Consumer Societies (Belkoopsoyuz) is conducting an assessment of the content of radioactive substances in products that are procured by consumer cooperative organizations.

The State Committee for Standardization monitors measurements of radioactive contamination of various objects.

There are 45 radiation monitoring points in the Republic of Belarus where the gamma radiation dose rate is measured daily. Particular attention is paid to 15 permanent monitoring points located in the Gomel, Mogilev and Brest regions.

In monitoring points, high levels of gamma radiation dose rate were detected in the cities of Bragin and Slavgorod. The dose rate of gamma radiation for the rest

of the territory of Belarus does not exceed the level of natural gamma background and is 0.20 μSv/h (20 μR/h).

Along with various radiation monitoring points, the Republic of Belarus has 4 automated radiation monitoring systems (ARMS). ARMS monitor the radiation situation in the zones of influence of various nuclear power plants: Chernobyl, Rivne (Ukraine), Ignalina (Lithuania), Smolensk (Russia).

Along with the radiation monitoring system, Belarus also has a **radiation control system for food products, food and agricultural raw materials, food and other forest products** produced in the territory affected by the Chernobyl disaster.

Various radiometric and spectrometric equipment is used to analyze radioactive contamination of food and other products. In addition, samples are analyzed annually for cesium-137 and strontium-90. The Ministry of Agriculture and Food has a network of radiation monitoring posts and laboratories.

At processing plants in radioactive contamination zones, there are 3 stages of control of raw materials and finished products: incoming, during the processing of raw materials, and finished products.

If high levels of radionuclides are detected in muscle tissue, cattle are returned to farms for special post-treatment. This measure includes feeding rations with low levels of radionuclides. A document is issued for each batch of finished products, which indicates the compliance of the radionuclide content with established standards.

In the Republic of Belarus, all activities to control the content of radionuclides in food products are considered licensed activities.

Measures to reduce the levels of radiation doses to people. To reduce the radiation dose to people living in the radioactive contamination zone, a set of measures is being carried out:

1. Limiting the intake of radionuclides into the body.
2. Reducing the absorption of radioactive substances.
3. Acceleration of the elimination of radionuclides from the body.

Measures to limit the intake of radionuclides into the body include:

1. Culinary and technological processing of food products.
2. Limit consumption of “local products”, especially berries and mushrooms.

1. When carrying out culinary and technological processing of food products, the following rules must be observed:

- Before cooking, mushrooms are cleaned of debris, washed and soaked in a saline solution. Then the mushrooms must be boiled several times with the broth drained. The above treatment helps to reduce the concentration of radionuclides by about 100 times;
- Before consumption, vegetables are cleaned of any soil particles, washed thoroughly, peeled and soaked, draining the brine;
- salting and marinating vegetables, fruits, and mushrooms can reduce the content of radioactive substances by 1.5–2 times (brine and marinade are not consumed);

- Before cooking, the meat is washed in running water, soaked in a salt solution, and after 2-3 hours, this solution is drained. Then a new portion of water is poured in, brought to a boil and drained again. Then a new portion of water is poured in and cooking is carried out;
- The reduction of radionuclide content in fish is facilitated by such measures as cleaning, removing the head and entrails, and rinsing in running water;
- Technological processing of food products helps to significantly reduce the content of radioactive substances. Thus, when milk is processed into cottage cheese, the content of cesium-137 decreases by 4-6 times. Butter contains 50 times less cesium-137 than the milk from which it is produced.

2. Limit the consumption of "local products", especially berries and mushrooms. To obtain recommendations on picking mushrooms and berries, you should contact forestry enterprises, forestry departments, as well as district hygiene and epidemiology centers. When harvesting berries and mushrooms, it is necessary to take into account the density of soil contamination with various radionuclides.

Birch sap must be collected in areas with a pollution density of up to 15 Ci/km2 · Birch sap must be collected in areas located in dry places. An increase in the content of cesium-137 is noted in birch sap of trees growing in humid conditions.

Measures that help reduce the absorption of radioactive substances include:

1. The principle of competitive substitution.
2. The principle of radionuclide binding in the gastrointestinal tract.

1. The principle of competitive substitution. Some radioactive substances and stable elements have common chemical properties. Thus, cesium is similar to potassium, strontium to calcium, plutonium to trivalent iron. Stable elements contained in food compete with radioactive elements and reduce their absorption (Table 13).

Table 13

Foods containing stable elements

Chemical element	Daily dose	Food products
Potassium	3 g	Wheat, rye, potatoes, raisins, prunes, dried apricots, tea, nuts, lemon, beans
Calcium	1 g	Milk and dairy products, eggs, legumes, green onions, dill, parsley
Iron	15–30 mg	Rye bread, meat, fish, green vegetables, sunflower seeds, apples, raisins

2. The principle of radionuclide binding in the gastrointestinal tract. There are a number of substances that form insoluble compounds with radioactive metal ions, i.e. bind radionuclides. Such substances include: pectins, phytates, anthocyanins. These substances are part of carbohydrates and are contained in plant products (Table 14). The formation of insoluble complexes promotes the removal of radionuclides from the body.

Table 14

Food products containing substances that bind radionuclides

Chemical element	Food products
Pectins	Eggplants, pears, beets, currants, carrots, apples, cucumbers, peppers, pumpkin, marmalade, marshmallows, juices with pulp
Phytates	Cereals, legumes
Anthocyanins	Plum, black currant, grapes, cherry

3. Acceleration of radionuclide removal from the body. This measure includes various methods of radionuclide removal (Fig. 37).

Increased intestinal peristalsis is promoted by eating foods containing fiber. Such foods include: whole grain bread; cereals (buckwheat, oatmeal, millet); vegetables (cabbage, beets, carrots); fruits (prunes).

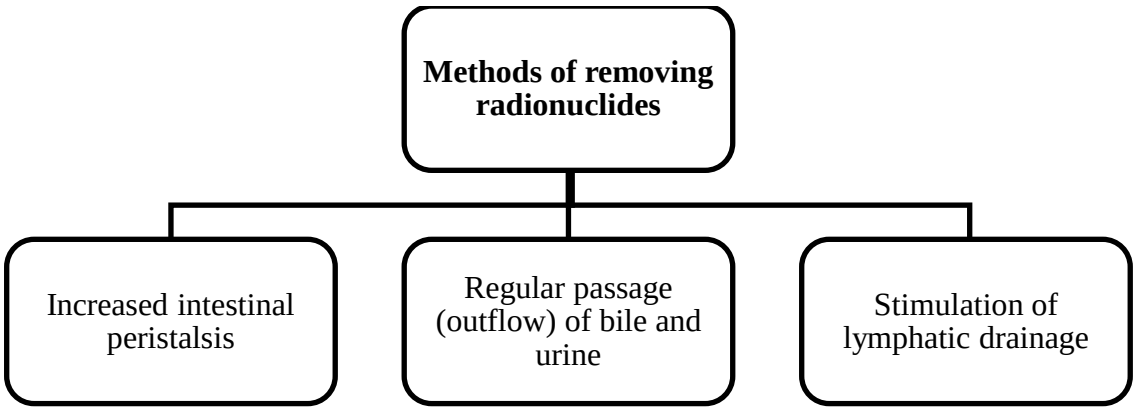


Fig.37. Acceleration of the elimination of radionuclides from the body

Regular passage of bile and urine is observed when using:

- additional amounts of liquids (tea, juices, fruit drinks, compotes);
- infusions of herbs with diuretic and choleretic effects (chamomile, St. John's wort, immortelle, mint, rose hips, dill).

Stimulation of lymphatic drainage. The lymphatic system is responsible for the functioning of detoxification processes in the human body. Medicinal herbs are the main stimulant of the human lymphatic system. Such herbs include: common oats (seeds, oat flakes), blackcurrant leaves, rose hips, plantain, calendula flowers.

Control questions

1. Describe the principles of radiation safety of the population.
2. Name the measures to protect the population from man-made radiation.
3. What does the term "Radiation Monitoring" mean?
4. Which structures of the Republic of Belarus carry out radiation monitoring?
5. Describe the radiation monitoring points and automated control systems on the territory of Belarus.
6. Name the measures to reduce the levels of radiation doses to people.
7. Describe the rules of culinary and technological processing of food products.
8. Describe measures that help reduce the absorption of radioactive substances in the human body.
9. Describe the measures taken to accelerate the removal of radionuclides from the body.

3. Fundamentals of ecology

Lecture 11. Ecological problems of nutrition. Main sources and consequences of drinking water pollution

Lecture plan:

11.1 Toxic chemical compounds formed in food products. Metals whose content is controlled in international trade in food products.

11.2. Substances used in agriculture, role in human pathology. Transgenic products.

11.3. Sources of chemical and radioactive contamination of drinking water, consequences for human health.

11.4. Bacteriological contamination of drinking water, methods of its purification and disinfection.

11.1 Toxic chemicals formed in foodstuffs. Metals controlled in international food trade

Toxic chemical compounds. The main toxic compounds formed in food products include **biogenic amines.** The source of these compounds are microorganisms. Products produced with the help of microorganisms have a high level of biogenic amines. For example, cheeses and beer. A significant amount of biogenic amines is also observed when food products spoil.

The main biogenic amines are: tyramine, serotonin, histamine.

Tyramine is found in large quantities in foods such as chocolate, cheese, beer, wine, and sauerkraut. Taking foods high in tyramine and certain medications at the same time can increase blood pressure. Some medications increase tyramine in the body. These medications include: antihypertensive (blood pressure lowering) and anti-tuberculosis drugs, antidepressants.

Serotonin, like tyramine, causes an increase in blood pressure. Serotonin is found in bananas, walnuts, tomatoes.

Histamine is found in significant quantities in red wine. Taking histamine in large doses can cause acute intoxication in the human body. This condition is characterized by severe headaches and smooth muscle spasms.

The main measures to reduce biogenic amines in food products are rinsing with water and changing the preservative liquid.

Metals. The cause of various pathological changes in the human body can be metals contained in food products, canned goods and dishes. 8 chemical elements have been identified, the content of which is controlled in international trade in food products: mercury, cadmium, lead, arsenic, copper, strontium, zinc, iron.

Cadmium. The average intake of cadmium per day is about 10 mg. It accumulates in significant quantities in the body of people who use nicotine. Cadmium is widely used in the manufacture of various pigments, alloys, protective coatings,

and chemical power sources. Its accumulation in the body is accompanied by obstructive diseases of the upper respiratory tract and severe kidney damage. Cadmium also has a mutagenic effect.

From muscle tissue and liver, the biological half-life of the above element ranges from 10 to 35 years.

Arsenic. It enters the body mainly with drinking water. The maximum concentration of arsenic in water is 40 mcg/l.

Chronic exposure to the human body is accompanied by depression, weight loss, and the development of cancer.

Arsenic is used in various areas of human economic activity: pharmaceutical (medicines for the treatment of syphilis and psoriasis) industry, microelectronic industry (semiconductors), in the production of pesticides, wood preservatives, etc.

Lead. Lead content in water is associated with anthropogenic activity: it enters water through soil and water supply systems. In Europe, the average concentration of lead in drinking water is 0.03 mg/l, but low water hardness and acidity increase its entry. Lead contamination of soil is also associated with automobile exhaust.

Lead accumulates in the body, and its half-life from bones reaches 30 years. The main part is excreted through the kidneys, and some accumulates in the hair and nails. Lead poisoning, or saturnism, develops gradually, accompanied by symptoms: headache, tremor, weakness, constipation, anemia and decreased immunity.

Lead is especially dangerous for children and pregnant women: it can cause premature birth, developmental delays in children, and increased irritability. Long-term exposure to lead leads to hyperactivity and aggression in children and hypertension in adults.

Mercury, which is a trace element, enters the atmosphere through natural processes (e.g. evaporation from the land surface, volcanic activity) and anthropogenic activity (burning of organic fuel, non-ferrous metallurgy). Anthropogenic mercury is more mobile and dangerous for the environment.

Getting from the atmosphere into the soil and water, mercury, being a highly toxic microelement, penetrates the human body through the respiratory tract in the form of vapors or dust. Particularly toxic are methyl- and ethylmercuric compounds, which easily penetrate membranes and accumulate in the liver, spleen, kidneys, affecting the nervous system.

Chronic exposure to mercury causes nervousness, memory impairment, depression, muscle weakness, loss of coordination, and also negatively affects the cardiovascular system and can lead to mercury poisoning.

Mercury is excreted through the lungs, gastrointestinal tract, kidneys and sweat glands, and the half-life is 40–76 days. Mercury intake should not exceed 0.3 mg per week, and a sign of chronic poisoning is a mercury content in the urine of more than 10 mg/day.

Copper is a common microelement in nature: its concentration in rivers and lakes reaches 7 μg/l, in soils - 15-20 mg/kg. Copper deficiency in the body can cause anemia, cardiovascular diseases and slow physical development in children. The

daily requirement for an adult is 2-2.5 mg, and copper enters the body mainly with food.

Although copper is slightly toxic, excess can cause nausea, vomiting, and hemolysis of red blood cells. Chronic intoxication leads to dysfunction of the nervous system, liver, and kidneys. Daily copper intake should not exceed 0.5 mg/kg of body weight.

Strontium, an analogue of barium and calcium, is present in all tissues of the body and is involved in bone formation, affecting the activity of some enzymes. In the soil, its content is about 600 mg / kg, which is safe for plants, but increased content (600-1000 mg / kg) can lead to strontium disease in humans. This disease, associated with excessive accumulation of strontium, is manifested by fragility and deformation of bones, probably due to blocking the biosynthesis of vitamin D.

Some properties of strontium, such as the goitrogenic effect and toxicity to nervous and muscular tissue, have not yet been sufficiently studied. Strontium is used in the production of batteries, refrigeration equipment, cosmetics and medicine.

Zinc, a trace element, significantly pollutes the World Ocean, where its concentration in surface waters is 10–20 μg/l. The main sources of zinc in the environment are wastewater from chemical, metallurgical and other industries.

The body of an adult contains 1–2.5 g of zinc: 60% in muscles, 30% in bones, and the rest in the liver and as part of metal proteins. The main routes of its excretion are through the intestines, sweat glands, and kidneys. Even in low concentrations, zinc in the air is mutagenic and oncogenic. Zinc is widely used to protect steel and iron from corrosion.

Iron is the second most common element in the earth's crust after aluminum, its content in natural waters varies from 0.01 to 26.0 mg/l. In biomass, iron is actively accumulated by aquatic plants, but to a lesser extent by animals.

The body of an adult contains 4–5 g of iron, and the daily requirement is 11–30 mg. It increases with intense physical activity, pregnancy and breastfeeding. A diet of foods containing iron is of great importance for the human body. Consumption of foods with a high iron content is associated with the risk of cardiovascular and allergic diseases, and water with an iron concentration of 2.0–5.0 mg/l can cause allergies.

The main route of iron removal from the body is through the gastrointestinal tract. Man-made sources of iron pollution include chemical, petrochemical, metallurgical and textile enterprises

11.2. Substances used in agriculture, role in human pathology. Transgenic products

In agriculture, a wide range of different substances are used to increase animal productivity:

Antibiotics. Half of the antibiotics produced in the world are used in animal husbandry as medicines and feed additives. When antibiotics enter the human body with food, various *allergic reactions can be observed*.

Vitamins are also used as supplements and medicines. Some vitamins, such as vitamin A, can accumulate in the liver of animals, which contributes to excessive intake by the human body. Its high content causes damage to the skin, damage to bone tissue, and swelling of the optic nerve.

Sex hormones are highly toxic. They can cause various oncological diseases in the human body. In the female body, they are associated with such diseases as *breast cancer and uterine cancer*, in the male body - *prostate cancer*.

Thyrostatic drugs are used to increase the weight of animals.

Sedatives are used in pig farming to prevent stress reactions. These drugs include: glucocorticoids (cortisone), β-blockers, valium.

cortisone enters the human body, it causes muscle cramps, high blood pressure and abnormal heart rhythms.

Signs of the effect of *β-blockers* on the human body include the appearance of weakness, deterioration in tolerance to physical activity, sleep disturbances, and depression.

As a result of the action *of Valium* in the human body, fatigue, visual impairment, and constipation occur.

Transgenic products. Genetically modified food is food products made from genetically modified organisms (plants, animals, microorganisms).

Genetically modified organisms are produced by transferring new genes. By acquiring new traits, plants facilitate soil cultivation and reduce costs associated with the use of herbicides.

Providing resistance to viruses. The most common method of providing plant resistance to viruses is *cosuppression* – transferring the virus gene into the plant. Having received the necessary gene, the plant produces the viral protein and promotes the formation of a protective reaction.

Providing resistance to insects. Resistance to harmful insects is provided by transferring the bacterial Bt toxin gene into the plant genome. This toxin is one of the most common insecticides used in agriculture. Currently, the Bt toxin gene is inserted into the genome of plants such as corn and cotton.

Ensuring resistance to fungi. One of the most common fungal diseases of plants is late blight. It mainly affects such plants as potatoes and tomatoes. Along with the use of fungicides to combat late blight, varieties resistant to this disease are bred.

Providing drought resistance. To artificially protect against drought, a gene from special strains of bacteria that are resistant to freezing is inserted into the plant genome.

Ensuring resistance to herbicides. In addition to selective herbicides, there are herbicides that affect the metabolic processes of almost all plant species. In order to ensure resistance to these substances, genes of various bacteria are transferred into the plant genome. One of the most resistant to herbicides of genetically modified plants is soybean.

Ensuring resistance to salinization and aluminum. One of the main problems of agriculture is soil salinization. This problem makes it impossible to use about

60 million hectares of fields. Currently, using genetic engineering methods, rapeseed is obtained that is resistant to salinization by sodium chloride.

Soil acidity is also a serious problem. Acidic soils are unsuitable for use and make up 40% of fertile land. In an acidic environment, aluminum compounds that are toxic to plants are formed. The most resistant plant to the effects of aluminum is rapeseed with an integrated Arabidopsis gene.

Pesticides are a class of chemicals used in agriculture. There are three main groups of pesticides:

1. **According to chemical composition,** pesticides are inorganic and organic. ***Organic pesticides*** are divided into: organochlorine, organophosphorus, organometallic, alkaloids (nicotine derivatives).

The greatest danger is posed by ***organochlorine pesticides.*** They are included in the group of persistent organic pollutants (POPs). Such pesticides are characterized by: high toxicity, resistance to destruction under the influence of environmental factors, mobility in the food chain, and a pronounced ability to accumulate in living organisms. The main purpose is to destroy harmful insects.

2. **According to their intended purpose,** the most common groups of pesticides include: herbicides, fungicides, insecticides, and zoocides.

Herbicides are pesticides that are used to control plant weeds.

Fungicides are chemical agents aimed at combating fungal diseases of plants.

Insecticides are chemicals used to kill insect pests.

Zoocides are pesticides that are used to kill harmful animals, mainly rodents.

3. **According to the method of penetration, nature and mechanism of action on organisms,** pesticides are divided into: contact, intestinal, systemic and fumigative .

Contact pesticides are substances that act on living organisms through direct contact.

Intestinal pesticides are chemicals that, when ingested with food, cause intoxication and death of the organism.

Systemic pesticides are preparations that penetrate the vascular system and cause the death of living organisms.

Fumigative pesticides penetrate through the respiratory system and cause intoxication of the body.

Due to the widespread use of pesticides worldwide, chronic diseases and deaths amount to approximately 1 million people per year.

11.3. Sources of chemical and radioactive pollution drinking water, consequences for human health

Nitrates are salts of nitric acid that form naturally and play an important role in plant nutrition, supplying them with nitrogen for protein synthesis. They always enter the human body in small quantities, and humans have developed metabolic adaptation mechanisms to assimilate them.

The main sources of nitrates are plants, water, air and food. In agriculture, they are widely used as nitrogen fertilizers (ammonium, potassium, calcium nitrate). If the rules for their use are not followed, excess nitrates can accumulate in plants, which creates a burden on the human body, especially in combination with natural sources of nitrates.

Air. Nitrate compounds are in the aerosol state in the air. Large quantities of suspended nitrates are found in cities polluted mainly by nitrogen oxides. The level of nitrate compounds in the air fluctuates between 1 and 40 mg/m^3 · Entering the human body with air in significant quantities, nitrates cause irritation of the upper respiratory tract.

Water. The nitrate content in surface and ground water varies from 0 to over 200 mg/l, in urban drinking water – about 10 mg/l. In areas with intensive agriculture, the concentration of nitrates in water is often increased, especially with abundant application of fertilizers.

Water with 8 mg/l of nitrates has a sour-salty taste, and at a concentration of 1500–2000 mg/l it becomes bitter and undrinkable. The toxicity of nitrates entering with water is higher than when entering with food, approximately 1.25 times.

Vegetables and fruits. Nitrates enter plants from the soil through the root system, concentrating mainly in leaves and root crops. Their level depends on the plant species. For an adult, the maximum permissible concentration (MPC) of nitrates per day is 325 mg, and the toxic dose is more than 600 mg. For children, the MPC is 5 mg per kg of body weight, but not more than 50 mg per day.

The maximum permissible concentration of nitrates in vegetables is 80 mg per 1 kg for onions, 1400 mg for beetroot and 2000 mg for fresh leafy vegetables (parsley, lettuce, dill). In fruits, the permissible level is 60 mg per 1 kg for apples.

Meat and fish products. The level of nitrates in natural meat products is insignificant and amounts to 5–20 mg/kg. Low levels of nitrates of 2–15 mg/kg have been found in chilled fish. It has been established that an increase in nitrates in the feed of cows and pigs by 6–10 times contributes to an increase in the content of these substances in muscles by 1.5–2 times.

The purpose of adding nitrates and nitrites to meat and some fish products is to: maintain color stability, improve smell and taste, and prevent the development of pathogenic microorganisms.

Cheese. To prevent the development of pathogenic microorganisms, nitrates and nitrites are used in cheese production. As the cheese matures, the nitrate content decreases to 30–140 mg/kg, and nitrites to 0.1 mg/kg.

Changes in the body associated with the action of nitrates.

When nitrates enter the body, they are transformed under the influence of carbohydrates, trace elements, pH levels and microorganisms, forming nitrites, nitrogen oxides and ammonia. Pathological changes are mainly associated with nitrites, which can be converted into nitroso compounds during metabolism. These substances contribute to skin diseases and have carcinogenic and mutagenic activity. In some countries, a link has been established between mortality from stomach cancer and the use of nitrate fertilizers.

Radon is a common radioactive element in drinking water, found primarily in granite, which is its primary source. Although radon concentrations are low in ordinary drinking water, they can be high in some wells and artesian boreholes.

Radon enters the human body through the lungs and gastrointestinal tract. Drinking water with radon can cause cancer in various organs, including the blood, gastrointestinal tract, and kidneys. In addition, radon, entering the body through the air, increases the risk of lung cancer.

11.4. Bacteriological contamination of drinking water, methods of its purification and disinfection

The population's drinking water supply is carried out from surface (lakes, rivers, reservoirs) and underground sources. Surface sources often have a high level of microbial contamination, a significant content of suspended particles and low mineralization. Bacteriological contamination is caused by runoff from the public utilities, tanneries, livestock farms and medical institutions.

Water contamination by pathogenic microorganisms (viruses, bacteria, protozoa) poses a serious threat to health, as it can cause outbreaks of infectious diseases. Water from surface and underground sources is safe for consumption only after special treatment, which includes purification and disinfection.

There are two main methods of water treatment: purification and disinfection.

1. Purification. Purification (clarification, decolorization) is the initial stage in the preparation of drinking water.

- ***Settling*.** At the first stage, water from surface sources enters through water intake grates, where large pollutants remain. Then the water enters large tanks – settling tanks. When water flows slowly (4–8 hours) through these tanks, large particles fall to the bottom.
- ***Coagulation.*** To settle small particles in settling tanks, various chemicals are added to the water, such as aluminum sulfate. This substance, under the influence of water, forms flakes to which small particles stick. Thus, small particles settle to the bottom of the tank. The sedimentation time of the particles is 2-4 hours.
- ***Filtration*.** This is the final stage of water purification. At this stage, water passes through a layer of sand and filter fabric. Filter materials retain 99% of microflora, helminth eggs and remaining substances.

2. Disinfection. Along with purification, disinfection of surface water is always necessary. When using underground water, disinfection is carried out only if the level of microorganisms in the water requires it. As practice shows, underground and surface waters are almost always impossible to use for drinking without disinfection.

Methods of disinfection aimed at destroying pathogenic microorganisms remaining in water after purification: chemical, physical, combined.

Chemical methods of water disinfection are: chlorination, ozonation, use of heavy metals.

Chlorination is the most common method of water disinfection, which is explained by the high efficiency of water disinfection, the low cost of chlorine and the simplicity of the equipment used.

When dissolved in water, chlorine destroys microorganisms, penetrating their shell and inhibiting the action of enzymes.

However, chlorine is highly toxic and the use of gaseous chlorine results in the formation of organochlorine compounds. These compounds are highly toxic, carcinogenic and mutagenic. Chlorination also worsens the organoleptic properties of water (colour, smell, taste).

Ozonation is one of the most effective methods of water disinfection. Ozone has a high bactericidal effect, improves the organoleptic properties of water and prevents the formation of carcinogenic substances. Its ability to quickly interact with microorganisms and turn into oxygen allows you to destroy pathogens 300-3000 times faster than other methods.

However, ozonation also has its disadvantages: high equipment cost, significant power consumption and short-term bactericidal action. In addition, when interacting with phenolic compounds, ozone can form toxic products that are more dangerous than chlorophenolic compounds. Even in small doses, ozone is toxic, so it must be controlled. It becomes safe only after converting into oxygen, when it does not form toxic compounds.

Use of heavy metals. Heavy metals such as copper, silver, bromine, and iodine are used to disinfect drinking water. The action of these substances is based on their ability to have a bactericidal effect in low concentrations.

Unlike chlorine, bromine and iodine compounds are characterized by more pronounced bactericidal properties. But the technology of using bromine and iodine, unlike chlorine, is more complex, and the use of silver in water disinfection is very expensive.

Physical methods of water disinfection include: boiling, ultraviolet disinfection, electric pulse method, ultrasound disinfection, and radiation method.

Boiling is one of the most common methods of disinfecting water, especially at home. This method destroys most microorganisms and various chemicals contained in water. The process of boiling reduces the hardness of the water and removes gases dissolved in it.

It is important to remember that some microorganisms retain their resistance when boiled briefly. For this purpose, water should be boiled for 15–20 minutes.

The use of boiling on an industrial scale is impractical due to the high cost of this method.

Ultraviolet disinfection is a promising method of water disinfection. The destruction of microorganisms by ultraviolet radiation is associated with the effect of this radiation on the enzyme system and cellular metabolism of microorganisms.

Water treatment is carried out using ultraviolet disinfection units (Fig. 38).

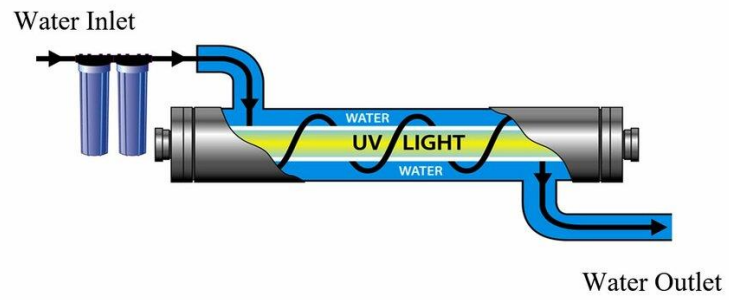


Fig.38. Installation of ultraviolet water disinfection

The ultraviolet (UV) water disinfection unit consists of a stainless steel body, inside which is a UV lamp with a quartz cover protecting it from contact with water. When passing through the unit, water is exposed to ultraviolet rays, which allows for the effective destruction of microorganisms without the formation of toxic substances. Due to this, the method has no upper dose threshold, and is considered environmentally friendly.

However, ultraviolet radiation, like ozone, does not have a long-term bactericidal effect, which can cause problems with centralized water supply, since there is a time interval between water treatment and its consumption. UV disinfection is more optimal for individual water supply systems.

In addition, long-term use of UV equipment can lead to the development of new strains of microorganisms that are resistant to this radiation. It is also important to consider that over time, the quartz lamp covers can become contaminated with chemical deposits, and turbid water can scatter ultraviolet rays, reducing the effectiveness of treatment.

The electro-pulse method is one of the new methods of water disinfection and is based on the use of pulsed electrical discharges.

The electro-pulse method is characterized by the formation of ultra-high pressure waves, intense ultrasonic vibrations, the emergence of pulsed electric fields, an increase in temperature, etc. This leads to the destruction of almost all pathogenic microorganisms and gives the water bactericidal properties that last up to 4 months.

This method of water treatment is environmentally friendly and allows the use of liquid in large volumes.

The disadvantage of using the electric pulse method is its high cost due to the consumption of a large amount of energy.

Ultrasonic disinfection is one of the newest and most promising, but expensive methods. The frequency of ultrasound is significantly higher than the human hearing level and ranges from 20,000 to 1,000,000 Hz. Ultrasonic vibrations of this frequency cause the destruction of microorganisms.

The mechanism of the bactericidal action of ultrasound has not been fully studied. There is an assumption that ultrasound leads to the destruction of bacteria by the formation of gas dissolved in the liquid. Gas bubbles contained in the bacterial cell contribute to its rupture.

Ultrasound is resistant to the effects of such factors as water turbidity, the number of microorganisms, and the presence of substances dissolved in water.

Radiation method. Radioactive radiation can also be used to disinfect water. Gamma radiation has the greatest bactericidal effect. There are special gamma installations in which water is treated under the influence of cobalt-60 radiation. Gamma radiation has a depressing effect on the enzymatic activity of microbes, and in large doses causes the death of pathogens of such dangerous infectious diseases as poliomyelitis, typhus, etc.

Combined method. The most effective in most cases is the combined method of water disinfection.

Thus, when combining chlorination and ultraviolet radiation, not only a high level of water treatment and a reduction in the threshold dose of chlorine in water is observed, but also cost savings when using this substance.

When using chlorination in combination with ozone, the formation of toxic organochlorine compounds is sharply reduced.

is one of the most dangerous infectious diseases that is primarily transmitted by water **.**

Cholera. The incubation period varies from a few hours to 5 days. The first sign is the appearance of loose stools. Then vomiting appears and the loose stools become more frequent. Watery stools are replaced by stools that look like "rice broth", with lumps of white mucus that form as a result of damage to the mucous membrane of the small intestine. Mucus and blood may also be present. Vomiting also looks like "rice broth".

Frequent loose stools and vomiting lead to dehydration, which causes circulatory problems, cessation of urination and renal dysfunction, possible development of coma, damage to the central nervous system, which can manifest itself in limb cramps.

Without treatment, the mortality rate can reach 80%. Cholera can cause not only local epidemics, but also global pandemics.

Potential risk of cholera epidemics after natural disasters, priority preventive measures. The risk of cholera epidemics increases significantly after natural disasters such as earthquakes, hurricanes, floods, droughts.

During earthquakes, the cause of the spread of the disease is damage to various objects: pumping stations, sewer networks, treatment facilities. This causes contamination of reservoirs, soil and underground water. Tsunamis that occur during earthquakes lead to floods and contamination of drinking water and food products.

The cause of the spread of cholera during hurricanes is heavy rainfall, rivers overflowing their channels, and the destruction of dams and dikes, which leads to flooding.

During very severe drought, the spread of this disease is caused by contaminated food products that flies have come into contact with.

Priority measures for cholera prevention after natural disasters:

1. Removal of drinking water supplies and food products that have been in contact with water.

2. Treating the surface of furniture, dishes and cutlery with boiling water.

3. Cleaning wells from dirt and washing hands thoroughly.

Control questions

1. Name eight chemical elements whose levels are controlled in international food trade.
2. What effects does lead have on the body?
3. List the main sources of mercury in the human body. Describe the symptoms that occur when exposed to mercury.
4. What consequences can copper deficiency lead to in the body?
5. Provide a definition of the term “Pesticides” and describe their classification.
6. Name the main sources of nitrates and describe the mechanism of their impact on the human body?
7. Formulate a definition of the concept "Transgenic products". Specify the purposes of their creation.
8. Name the sources of surface water pollution.
9. What methods of water purification do you know? Describe the methods of water disinfection.
10. Give a definition of cholera, list the main symptoms and measures to prevent the disease.

Lecture 12. Legislation of the Republic of Belarus in the field of environmental protection and rational use of natural resources

Lecture plan:

12.1. Legislation of the Republic of Belarus in the field of environmental protection. Main directions of state policy in the field of environmental protection.
12.2. Current state of the environment in the Republic of Belarus. Unresolved environmental problems at the present stage. National environmental monitoring system (NEMS).
12.3. Specially protected natural areas of the Republic of Belarus. International activities of the Republic of Belarus in the field of environmental protection.

12.1. Legislation of the Republic of Belarus in the field of environmental protection. Main directions of state policy in the field of environmental protection.

The main regulatory and legal acts in the field of environmental protection and rational use of natural resources are:

1. Law of the Republic of Belarus "On Environmental Protection" No. 126-Z of July 17, 2002
2. Law of the Republic of Belarus "On the Plant World" No. 205-Z of June 14, 2003.
3. Law of the Republic of Belarus "On the Protection of Atmospheric Air" No. 2-Z of December 16, 2008

4. Law of the Republic of Belarus "On the Protection of the Ozone Layer" No. 56-Z of June 16, 2014

5. Code of the Republic of Belarus "On Subsoil" dated July 14, 2008

Let's look at them briefly.

1. The Law of the Republic of Belarus "On Environmental Protection" of July 17, 2002 defines:

- the main tasks aimed at solving environmental protection issues;
- the main directions of the state policy of the Republic of Belarus in the field of environmental protection;
- requirements for the use of hazardous chemical and radioactive substances;
- standards for permissible emissions and discharges of chemical and other substances;
- waste handling requirements;
- requirements for sources that have a harmful physical impact. Standards for permissible physical impacts (heat, noise, ionizing radiation, electromagnetic fields);
- protection of the ozone layer;
- specially protected natural areas (nature reserves, wildlife sanctuaries, national parks)
- environmental monitoring;
- international cooperation in the field of environmental protection, etc.

2. The Law of the Republic of Belarus "On the Plant World" of June 14, 2003 includes:

- protection of flora from fires;
- protection of flora objects using plant protection products, mineral fertilizers and other preparations;
- protection of flora and fauna in specially protected natural areas;
- landscaping and reproduction of flora;
- monitoring of flora, etc.

3. The Law of the Republic of Belarus "On the Protection of Atmospheric Air" of December 16, 2008 defines:

- standards for permissible emissions of pollutants into the atmosphere;
- requirements in the field of atmospheric air protection when using plant protection products and mineral fertilizers;
- requirements in the field of atmospheric air protection during combustion of fuel, substances, materials and waste;
- atmospheric air monitoring, etc.

4. The Law of the Republic of Belarus "On the Protection of the Ozone Layer" of June 16, 2014 presents:

- requirements in the field of ozone layer protection during maintenance, repair, and dismantling of equipment containing ozone-depleting substances;
- recovery, neutralization and disposal of ozone-depleting substances;
- information on the import and export of ozone-depleting substances and

products containing them;

- ozone layer monitoring.

5. The Code of the Republic of Belarus "On Subsoil" of July 14, 2008 establishes: requirements for the extraction of co-occurring minerals, basic requirements and regulations in the field of subsoil use and protection, safety requirements for subsoil use, etc.

The main types of liability for violation of environmental legislation include:

1. Special environmental and legal.
2. Civil law.
3. Disciplinary.
4. Administrative.
5. Criminal.

12.2. Current state of the environment in the Republic of Belarus. Unresolved environmental problems at the present stage. National Environmental Monitoing System (NEMS)

Current state of the environment in the Republic of Belarus. Unresolved environmental problems at the present stage. Anthropogenic factors have a great influence on the environmental situation in Belarus. The sources of anthropogenic factors impact on the environment are: housing and communal services, agricultural activities, transport, industrial and energy enterprises.

The main environmental problems of Belarus include:

1. Problems associated with the depletion of natural resources are caused by large-scale drainage reclamation (over 3.5 million hectares) carried out in the 1960–1980s in the Republic of Belarus.

2. Problems caused by environmental pollution include: radioactive contamination of the territory, air pollution, surface and ground water pollution, accumulation of industrial and municipal waste. Therefore, it is necessary to actively collect and recycle garbage .

The most important environmental problem is radioactive contamination of the territory.

Persistent organic pollutants.

The list of persistent organic pollutants includes 24 names. The specified list is expanding as information on the properties of hazardous chemicals accumulates. Among POPs, chlorine-containing pesticides constitute a whole group.

As a result of monitoring observations of the condition of storage sites for obsolete pesticides, the following problems were identified:

- unsatisfactory condition of storage facilities (roof damage, discrepancy between the size of storage facilities and the amount of chemicals stored there, etc.);
- violation of pesticide accounting rules;
- formation of new chemicals with unknown properties (mixing of pesticides during the process of their repackaging in plastic containers);

- storage of repackaged pesticides, resulting in deformation of the barrels and the risk of emergency situations.

Measures to eliminate obsolete pesticides classified as persistent organic pollutants in Belarus are planned to be completed by 2025.

The National Environmental Monitoring System (NEMS) is an information system on the state of the environment that combines the means of collecting information and all stages of its processing before transmitting the information to consumers.

The main goal of creating the NSMOS is to consolidate disparate environmental information and provide all levels of government with objective data for making operational decisions and determining environmental management strategies.

The organization and implementation of monitoring is carried out by republican government bodies (Table 16).

Table 16

Structure and functions of the National Environmental Monitoring System

Republican bodies of state administration	Type of monitoring
Ministry of Natural Resources and Environmental Protection	Atmospheric air monitoring, surface water monitoring, groundwater monitoring, local monitoring (monitoring of small areas), radiation monitoring
National Academy of Sciences of Belarus	Monitoring of fauna, monitoring of flora, geophysical monitoring
Ministry of Education	Ozone layer monitoring
Ministry of Forestry	Forest monitoring
State Property Committee	Land monitoring

12.3. Specially protected natural areas of the Republic of Belarus. International activities of the Republic of Belarus in the field of environmental protection

Specially protected natural areas (SPNA) are parts of the territory of the Republic of Belarus with unique natural complexes and objects of special ecological and aesthetic significance and for which a special regime of protection and use has been established.

Protected natural areas are defined by the Law of the Republic of Belarus “On Specially Protected Natural Areas”.

There are 4 categories of protected areas depending on the functions and modes of protection and use (Fig. 39).

A ***reserve*** is a specially protected natural area declared for the purpose of preserving valuable natural complexes and objects, studying living organisms and natural ecological systems (terrestrial, aquatic), and creating conditions for ensuring the natural course of natural processes.

A national park is a specially protected natural area declared for the purpose of restoring and preserving valuable natural complexes and objects, and their use in the process of various environmental activities (nature conservation, scientific, educational, tourist, recreational and health-improving).

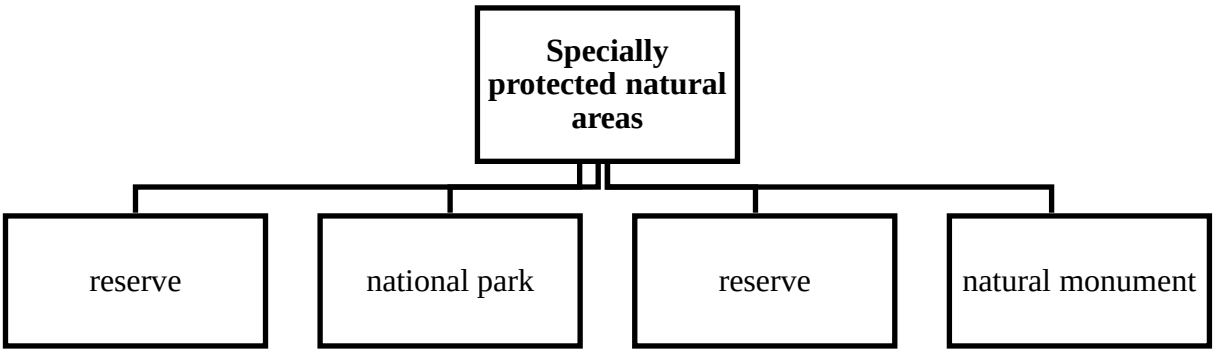


Fig. 39. Protected natural areas depending on the functions and modes of protection and use

A nature reserve is a specially protected natural area declared for the purpose of restoration, conservation and reproduction of natural complexes and objects, natural resources of one or several types with restrictions on the use of other natural resources.

A natural monument is a specially protected natural area declared for the purpose of preserving valuable natural objects in the interests of present and future generations.

Unlike reserves and national parks, any economic activity is completely prohibited on the territory of reserves: mining, hunting, fishing, etc. In these territories, tourism activity is limited.

Natural monuments include centuries-old trees, parks, hills, ditches, etc.

80% of rare and endangered wild plant species are registered within the boundaries of specially protected natural areas. In addition, about 90% of rare and endangered wild animal species live in these areas. The area of specially protected natural areas is 8.2% of the total area of the country.

International activities in the field of environmental protection are defined by agreements, protocols and conventions.

Control questions:

1. Name the main types of liability for violation of environmental legislation.
2. What are the unresolved environmental problems in Belarus?
3. What measures are being taken in the Republic of Belarus to reduce the growth of emissions of various pollutants?
4. What natural and anthropogenic factors influence the quality of underground drinking water?
5. Name the problems identified as a result of monitoring the condition of storage sites for obsolete pesticides.
6. Formulate a definition of the concept "National Environmental Monitoring System". State the purpose of its creation and its main functions.
7. Which republican government bodies organize and conduct environmental monitoring?
8. What categories of specially protected natural areas, depending on their functions and protection regime, exist in the Republic of Belarus?
9. What is the share of specially protected natural areas in the total area of the country?

4. Fundamentals of energy saving

Lecture 13. Fuel and energy resources in the Republic of Belarus and traditional methods of obtaining thermal and electrical energy

Lecture plan:

13.1. Fossil fuels, their characteristics and reserves in the Republic of Belarus.

13.2. Energy, its types. Traditional sources of electrical energy: thermal, water flow energy, atomic energy.

13.3. Environmental problems of using traditional energy sources.

13.1. Fossil fuels, their characteristics and reserves in the Republic of Belarus

According to their physical state, there are three types of fuel: solid, liquid, and gaseous.

Solid fuel. Solid fuels include plant components such as wood, reeds, straw, and corn. As a result of humification of organic matter, solid fossil fuels are formed (excluding shale).

Wood, peat, brown coal, oil shale are the fuel resources that are widely distributed in the Republic of Belarus.

Nuclear fuel. Heavy nuclei of thorium and uranium are the only natural type of nuclear fuel. When the isotope ^{235}U, which is present in natural uranium in an amount of 0.7%, is fissioned, energy is released in the form of heat. ^{239}Th and ^{238}U can be used as raw materials. These isotopes, under the influence of neutron irradiation, become new nuclear fuel: ^{239}U and ^{239}Pu. In 1 kilogram of uranium we get as much energy as the combustion of 2700 tons of high-quality coal.

Nuclear fuel is actively used in reactors, where it is stored in the form of small pellets in sealed fuel elements.

Liquid fuel. A significant portion of liquid fuel is obtained by refining oil. Its distillation produces such products as kerosene, gasoline, various lubricating oils, and also Vaseline, which is used in medicine.

After extraction, oil must be heated to approximately 350°C, then the resulting steam must be distilled into fractions: diesel (18%), kerosene (17%), gasoline (15%), liquefied gas (1%). The remainder after processing is fuel oil.

The country's key oil reserves are located in the Pripyat Trough area. There are 55 known oil sources, including 53 in the Gomel Region and 2 in the Mogilev Region. One of the significant deposits being developed is the Rechitsa field, which has been in operation since 1965.

Gaseous fuel. The most common representative of gaseous fuel is natural gas. Its basis is CH4 (methane). There is also associated gas obtained during oil production. Its feature is a lower content of methane and a higher content of higher hydrocarbons than in natural gas.

Gas underground is located under pressure in unique waterproof domes made of clay and sandstone. It consists mainly of CH4. Condensate droplets, sand suspension and other inclusions are removed from the gas when it leaves the well. Then it is fed to the main gas pipeline, which has a diameter of about 1 meter and a length of several thousand kilometers. The average pressure in the gas pipeline is 5 MPa. This pressure is maintained by compressors installed every 100 meters. The compressors operate from the gas in the gas pipeline and consume about 11% of all gas. Therefore, gas transportation is quite expensive.

In Belarus, proven gas reserves amount to approximately three billion m^3, of which 0.3 billion m^3 is natural gas.

One of the most promising types of fuel is hydrogen. Compared to oil, it has 3 times more energy capacity. Almost all hydrogen is now obtained from natural gas, but in the foreseeable future it can be obtained as a result of coal gasification. Hydrogen can be obtained through the electrolysis of water.

13.2. Energy, its types. Traditional sources of electrical energy: thermal, water flow energy, nuclear energy

Energy is a single numerical measure of the motion and interaction of all types of matter. Energy is the ability to perform work, and work is performed when a physical force acts on a body.

There are several types of energy. These include: mechanical, electrical, thermal, magnetic, and atomic energy.

Electricity is one of the most common. It is widely used because it can be obtained from various renewable sources, is environmentally friendly, is easily converted into various types of energy, and is easy to transport.

Thermal energy is widely used both in industry and in everyday life. It is used in the form of steam - the result of combustion of fuel or hot water.

In our country, a significant portion of energy (more than 90%) is produced at thermal power plants.

Thermal power plants (TPPs) produce electricity using heat energy from the combustion of organic fuels such as coal and gas. They have become the main source of energy since the 1970s and include combined heat and power plants (CHPs), which also provide heat. CHPs are less reliable due to high losses during heat transfer. In Belarus, the capacity of power plants is 9,741 MW, of which 97% are TPPs. Lukomlskaya GRES with a capacity of 2.9 GW is the largest in the country, and in the world - Tuoketuo in China with a capacity of 6,600 MW.

A hydroelectric power station (HPP) is a complex of structures that converts the energy of a water flow into electrical energy. A HPP includes hydraulic structures and equipment where the water flow rotates a hydraulic turbine connected to a generator. There are several types of HPPs: run-of-river, dam and diversion, depending on the method of using water and the pressure level.

The operating principle is elementary and is practically identical everywhere. The water pressure, which is directed at the blades of the hydro turbine, causes it to

rotate, and the hydro turbine, in turn, being connected to the generator, rotates the generator. The generator produces electricity, which is fed to the transformer station, and then to the power transmission line.

The capacity of a HPP depends on the volume and pressure of the water. The largest HPP is the Three Gorges HPP on the Yangtze River in China (22,500 MW). As of January 1, 2020, there are 25 HPPs in operation in Belarus with a total capacity of 88.26 MW.

Pumped storage power plants (PSPP) are used to smooth out fluctuations in electrical load during the day. They work with pumps and generators, pumping water into the upper pool at night, when energy is cheaper, and releasing it during the day to generate expensive electricity. PSPPs are effective in large energy systems where the main sources are nuclear and thermal power plants that are not able to quickly regulate energy production. The largest PSPP is Bass County in the USA (3003 MW). Belarus is discussing the possibility of creating its own PSPP.

Nuclear power plants (NPPs) produce electrical energy by converting nuclear energy. The main element is a nuclear reactor, where the fission of heavy elements releases heat, which is used to generate electricity. NPPs operate on nuclear fuel such as uranium and plutonium, the reserves of which significantly exceed those of organic fuel, which gives them an advantage. The increase in the cost of organic fuel creates economic problems for developing countries, which emphasizes the need to develop nuclear energy. In Belarus, a NPP is being built 18 km from Ostrovets with a design capacity of 2400 MW. The most powerful NPP in the world is Kashiwazaki-Kariwa in Japan (7965 MW).

13.3. Environmental problems of using traditional energy sources

Environmental issues in thermal energy. Combustion of coal, wood and other natural resources produces about 89% of energy, while the share of thermal sources in the electricity industry is 81%. In developed countries, oil is more often used for transport, and coal remains the main source of electricity in countries such as China (76%).

Combustion of fuel results in emissions of harmful substances, making thermal power plants a leading source of greenhouse gases and acid rain. Thermal power plants emit about 51% of carbon, 36% of nitrogen oxides and 34% of dust into the atmosphere. It is estimated that nuclear power plants have 2-4 times less impact on the environment with radioactive substances than thermal power plants of the same capacity.

Emissions from thermal power plants contain significant amounts of metals: more than 110 million doses of aluminum, 400 million doses of iron and about 1.5 million doses of magnesium. Thus, thermal power plants have a negative impact on the environment, including soil, water and forests.

Environmental problems of hydropower. The creation of reservoirs during the construction of hydroelectric power plants floods millions of hectares of fertile land and destroys ecosystems (for example, in Russia about 6 million hectares are

flooded). This also leads to flooding of lands, which become swampy, and coastal erosion, which destroys natural communities.

These processes can last for decades and lead to soil processing, silting of reservoirs and water pollution. Ecosystems end up under water, which increases the amount of organic matter and creates conditions for the overgrowth of water bodies with algae and bacteria. This worsens the quality of water, reduces oxygen and leads to the death of aquatic inhabitants, including helminth infection.

Fish migration changes, spawning grounds and feeding grounds are destroyed. Therefore, when constructing reservoirs, it is important to minimize changes in the hydrological regime of rivers and ecosystems to reduce the negative impact on the species composition of aquatic organisms.

Environmental problems of nuclear energy.

Nuclear power plants (NPPs) have advantages such as an abundance of nuclear fuel and minimal environmental impact during standard operation. Nuclear fuel is economical to transport because it is required in small quantities.

Since the end of the 20th century, the share of nuclear power plants in the world's energy supply has increased to 16%. However, there are serious drawbacks, including difficulties in disposing of spent nuclear fuel and the high costs of dismantling old plants.

Key issues with nuclear power plants include ecosystem destruction due to fuel extraction, land acquisition, deterioration of water quality due to water abstraction, and risks of radioactive contamination. This highlights the need for careful handling of nuclear energy and strategies to reduce its negative impacts.

Control questions

1. Please describe the fossil fuels most commonly used in the Republic of Belarus as an energy source?
2. Name the environmental problems that arise as a result of using traditional sources of electricity.
3. What chemical elements are used as raw materials for nuclear fuel?
4. Where are the main oil reserves located in the Republic of Belarus?
5. Does the Republic of Belarus have natural gas reserves? Why is natural gas transportation so expensive?
6. Name the reasons for the increase in the use of electrical energy in the world.
7. Give a description of thermal power plants. What is the difference between thermal power plants and combined heat and power plants?
8. Describe the operating principle of hydroelectric power plants.
9. What are the advantages of nuclear energy? Describe the operating principles of nuclear power plants.
10. Is there an operating nuclear power plant in the Republic of Belarus? What are its main characteristics?

Lecture 14. Renewable energy sources

Lecture plan:

14.1. Brief description of renewable energy sources: sun, wind, ocean tides, geothermal energy.

14.2. The concept of bioenergy. Use of biomass energy in the world and in the Republic of Belarus. Biogas.

14.1 Brief description of renewable energy sources: sun, wind, ocean tides, geothermal energy

At the moment, there are many different reasons why humanity is thinking about renewable energy. One of them is the threat of global climate change, which calls into question the further increase in the use of fossil hydrocarbon fuels.

The sun is considered an environmentally friendly and generally accessible source of energy on the planet. The development of science and industry makes it possible to talk about the real ability to provide the population of the earth with electricity by using the energy of the sun. This technology does not produce harmful waste during use. Solar energy has many different uses, it can be used to heat water in heating systems and hot water supply.

Since ancient times, solar thermal energy has been used for heating a surface, distributing and introducing heat, i.e. focusing solar radiation on a vessel with water or salt for further use of water in heating, water supply or using it as a driving force. The simplest method for a summer house is a dark barrel of water on the roof, this has been done for centuries.

However, modern solar water heating systems use highly efficient solar collectors - special plates with an increased absorption coefficient, which are placed on the roof, facade or ground at a specific angle to the horizon. They are made of cheap materials and metals such as steel, copper, aluminum. This helps to significantly reduce the cost of equipment and the energy obtained from it. Today, heating water naturally is considered the most rational and effective method of converting solar energy.

The sun is an inexhaustible source of energy, which has become widespread in the Republic of Belarus. Significant potential for energy saving in this area is due to the fact that heat supply needs today account for about half of the total volume of fuel and energy resources consumption in Belarus.

The operating principle of a solar thermal power plant is shown in the video in Fig. 40.

How a solar battery works

Solar panels began their history in the 20th century, and their operating principle has remained the same to this day, while the materials and the device scheme used in production have been modernized. With this, one of the most important criteria is gradually increasing - the photoelectric conversion coefficient or efficiency of the device.

The magnitude of the output current and voltage of the solar battery directly depends on the level of external illumination that affects it. The Japanese corporation Sharp is a leader in the production of solar panels with transparent photocell accumulators for glazing window openings.

Fig. 40. Solar thermal power plant. (Video 4 min 58 sec) https://www.youtube.com/watch?v=xKxrkht7CpY

In the recent past, the converter panel consisted of two thin plates of pure silicon, stacked together. Boron was applied to one plate, and phosphorus to the other. Free electrons appear in the layers covered with phosphorus, and their deficiency occurs with boron. Under the influence of sunlight, electrons begin to move particles and an electric current arises between the plates. To remove the current from the plates, they are soldered with thin strips of specially treated copper. One silicon plate is enough to charge a small flashlight. Accordingly, the larger the area of the panel, the more energy it produces.

The UV-transmitting plates are welded together, laminated with film and attached to the glass. The bonded layers are enclosed in an aluminum frame (Fig. 41).

Fig. 41. External appearance of the solar battery. (Video 04 min 53 sec)) https://youtu.be/BZ8H-tFvQ1I

The solar battery structure uses *a p-n* junction and a pair of electrodes to remove the output voltage. The top layer of the *p-n* junction, which has an excess of electrons, is connected to metal plates that act as a positive electrode, transmitting light and giving the element additional rigidity. The bottom layer in the solar battery structure has a shortage of electrons and a solid metal plate is glued to it, acting as a negative electrode.

The transfer of energy from a solar power plant to a consumer can be studied using Fig. 50.

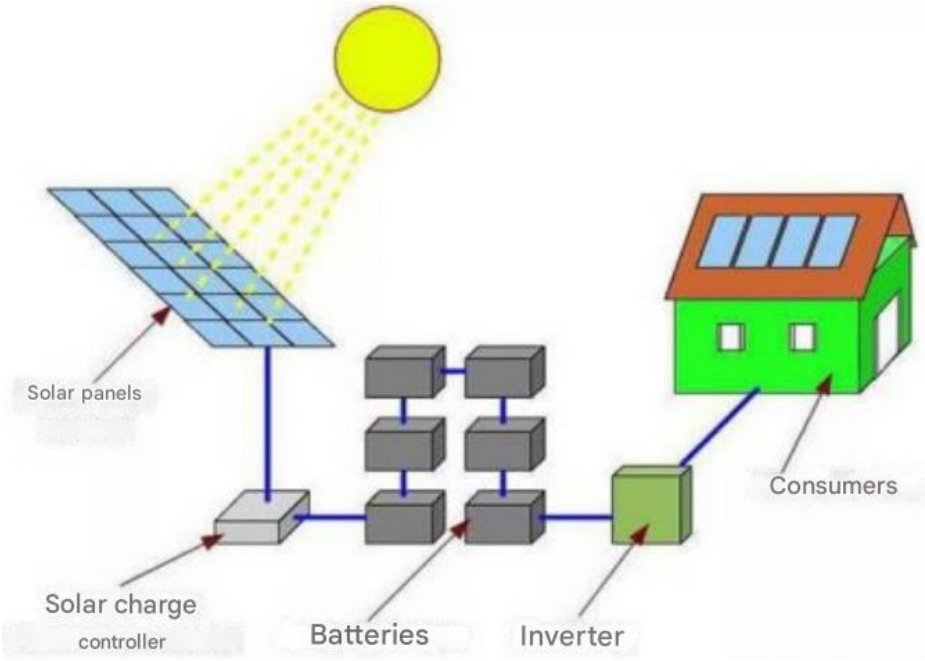


Fig. 50. Operating principle of a solar power plant

Wind energy.

Wind power has been known for thousands of years. Wind power was used by sailors at the dawn of civilization. According to scientists and historians, the ancient Egyptians sailed five thousand years ago. Approximately in 700 AD in the lands of modern Afghanistan, wind-powered structures with a vertical axis of rotation were used to grind grain into flour. The windmills we know today kept the irrigation system (a system with a main channel and branch channels flowing out of it, supplying water to the fields) of the island of Crete running. Windmills for grinding grain are rightfully considered one of the most important discoveries of the Middle Ages in the field of technology.

Wind energy is an energy industry based on the change of energy of air masses in the atmosphere from kinetic to thermal, mechanical, electrical or another form of energy for its rational use in everyday life and industry (Fig. 51).

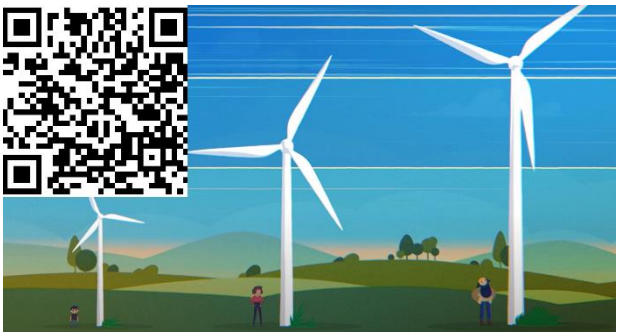


Fig. 51. The principle of operation of a wind turbine. (Video 5 min 2 sec) https://www.youtube.com/watch?v=xy9nj94xvKA

This energy is obtained using devices such as a wind generator (to generate electricity), a sail (to move with the help of winds), a windmill (to convert into mechanical energy).

Research, various tests and experiments have pushed technological progress in the field of using wind power. It is indisputable that the greatest potential of wind energy is located near sea coasts and cliffs, on highlands or in the mountains.

But even on flat areas or meadows, lowlands, one can find considerable wind potential, which allows using its energy everywhere.

If we pay attention to the disadvantages of this energy, then the wind is considered the least predictable, unlike the sun, in certain periods there may be no wind for a whole day or even more. This makes it difficult to extract energy.

Currently, there are more than 23 wind turbines operating in Belarus. The largest wind turbine in Belarus is located in the village of Grabniki in the Novogrudok district of the Grodno region: its capacity is 1.5 MW. The wind turbine near Novogrudok still remains the largest and most powerful in Belarus.

At the moment, wind should provide Belarus with 2–5% of the country's total energy balance.

The design of the wind turbine is shown in Fig. 52.

Several criteria are important for wind energy production:

1. Location dependent.
2. Seasonal dependence.
3. Complexity in production, resource prices, methods of improving the design, as wind turbines contain many complex parts and require extreme reliability.

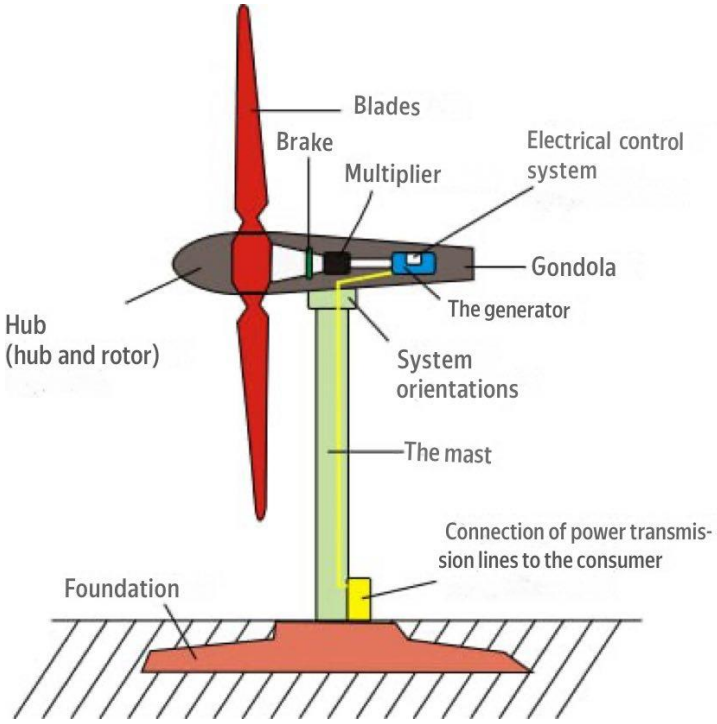


Fig. 52. Wind power plant design

The world leaders in the development of wind energy are countries such as the USA and China. Others are also beginning to develop this promising direction in energy. Statistics show that more and more wind generators are being installed on Earth, which means that the rate of use of wind energy is increasing.

The advantages of using wind energy:

1. Wind does not require fossil fuels to move and is not scarce.

2. An energy-clean mechanism for generating energy.

3. Mobility and space saving, which is very useful in agriculture. The operating parts of the turbine are located at a significant level above the ground, and the vertical pipe takes up little space on the ground, so the entire area can be used for agriculture. For example, various buildings and structures needed for the farm can be placed in these areas.

4. The requirement for maintenance and repair is minimal.

5. This is relevant for isolated areas where energy cannot be supplied by standard means.

Disadvantages of using wind energy as a resource:

1. Difficulty in transportation and installation.

2. Certain monetary and resource costs are required.

3. Strong dependence on weather and natural conditions in a given time interval. Simply put, the wind can blow strongly, weakly or not at all, and to ensure a continuous supply of electricity to the consumer in such variable conditions, a system for storing energy of a certain capacity is needed. In addition, it must be transmitted in some way.

4. There is an incredibly small chance that a bird will collide with one of the blades of a windmill. And nocturnal mammals like bats are more vulnerable to injury if they enter the low-pressure areas near the edges of the blades.

5. Some scientists believe that wind turbines change the natural landscape. Therefore, it is necessary to take into account all the features of the location and installation of the wind turbine.

Although wind turbines have significant disadvantages, they remain in demand and popular in use around the world due to the reduced load on fossil resources. For clarity, the difference can be shown in comparison with natural non-renewable resources and the operation of a wind generator with a capacity of 1 MW. This makes it possible to save about 14,500 tons of coal or approximately 46,000 barrels of oil over 10 years.

The main elements of wind turbines are:

1) wind wheel;

2) electric generator;

3) a system for controlling the parameters of generated electricity depending on changes in wind force and wind wheel rotation speed;

4) Since periods of calm are inevitable, in order to avoid interruptions in the power supply, wind turbines must have electric energy *storage batteries* or be connected to other types of electric power plants.

5) The battery is a necessary element of the system, which is an accumulator and redistributor of energy, which ensures the reliability of the power supply. The controller is necessary for controlling the rotation of the blades, charging the batteries and performs protective functions. The inverter converts the current from direct to alternating, stabilizes the output voltage. Thanks to these components, a reliable power supply is ensured both in gusty winds and in windless weather. Many models of wind turbines provide for the orientation of the blade installation angle to increase

the output power, as well as protection from strong winds (transfer of the wind wheel to the weathervane position).

The Belarusian energy program envisages the use of wind energy resources to drive pumping units and as energy sources for electric motors. Their use in combination with small hydroelectric power plants for pumping water is considered especially promising.

The power of a wind generator depends on the area occupied by the generator blades. For example, 3 MW turbines (V90) produced by the Danish company Vestas have a total height of 115 meters, a tower height of 70 meters and a blade diameter of 90 meters.

Ocean Tidal Energy

Wave energy is energy that is obtained using any waves, salinity levels, various currents, tides, and temperature differences in any body of water in the world.

If we consider this energy as a resource, it is quite unstable, just like the wind energy described above. In many countries around the world, work is being done to study the possibilities of using ocean thermal energy. The advantages and disadvantages of this type of energy resource can be judged by the results of this work.

There are several ways to use tidal energy:

The first method involves obtaining energy directly from the tides. That is, during high tide, when the water level rises, the necessary device or reservoir can be filled. With the help of tides, various turbines can be installed along the path of the water current, with the help of which electricity is obtained. The water current during low tide can rotate the turbine if reverse rotation is allowed at the stage of designing the mechanism. There are not many stations of this type. For example, a tidal station operated at the mouth of the Severn River, located in England.

The second method is the operation of power plants by installing generators directly in the ocean to extract wave energy. This type of energy extraction is possible even in river mouths, if the force of the water flow is calculated in advance and a dam of the required height is built.

This power plant operates according to the following scheme: waves periodically compress the air inside a vertically located chamber. Coming out of the chamber, the air moves the blades of the turbine placed inside. When descending, the flow creates an empty air space inside the cylinder and thus continues to rotate the turbine. The main problem was the need to ensure that the turbine rotates in the same direction with direct and reverse air flow.

The world's wave energy reserves total about three billion kilowatts. The main problem with its use is that it is necessary to find cheap but high-quality ways to convert the energy of moving waves into mechanical or pneumatic form because sea waves are unpredictable in length and have different amplitudes. This means that any effective device must either be broadband or have frequency regulation.

The principle of operation of wave power plants. The device consists of a vertically positioned pipe, immersed with its open end down into the calm layers of the water column and closed at the top. The pipe is attached to a float. Above, in the wave chamber, between the water level and the cover, there is free space occupied

by air. The water level in the wave chamber increases when the wave level rises. As a result, the air in the free space is compressed and activates an air turbine connected to an electric generator. When the wave decreases, the oscillation period of which is 5-6 seconds, a new portion of air is drawn into the wave chamber through the air valve. And then the process will be repeated again and again.

Possible solutions for energy production based on the use of various water devices and stations:

1. Rational use of the force of horizontal movement of sea water using weather vanes to generate energy through rotating devices installed directly on the water.
2. The possibility of using the increase and decrease of the vertical wave level to drive air and water turbines connected to electric generators.

Ocean Thermal Energy

Obtaining energy from the temperature difference in water layers is still being developed and studied by scientists. Of the various methods of obtaining renewable energy, such as wind and solar, thermal energy of the ocean is singled out as the most reliable. It changes the least over time. Modern technologies have made it possible to move from theory to practice. Experimental installations were deployed in Hawaii, where the temperature gradient of the water layers on the surface and at a depth of 1 km reaches 25 degrees. This unique experimental installation is built on the principle of a heat pump, consisting of a condenser, evaporator and compressor. In a closed loop of the system, the working fluid is freon in various states. The evaporator is heated by surface water to about 30 degrees, the condenser is cooled by bottom water to about 5 degrees. In the evaporator, freon passes into a gas state and enters the turbine, rotates the generator and then enters the condenser and is compressed there to pass into a liquid state. In the World Ocean, you can choose the most advantageous places with the best temperature difference.

Stations built on the principle of thermal energy can be floating or stationary.

For floating ones, it is easier to find favorable conditions - to increase efficiency. But the problem of conservation (or use on site) and removal of generated energy arises. There are projects where electricity is spent on electrolysis of water to decompose it into oxygen and hydrogen with subsequent use of hydrogen in fuel cells. There are projects of desalination plants, where the product of a floating power plant is fresh water. For stationary systems, standard infrastructure is cheaper and more familiar.

If we analyze the economics of ocean thermal energy, the breakeven point occurs at an average temperature gradient of water layers of about 22 degrees. The floating power plant projects under development with a capacity of up to 500 MW could provide gas, oil, etc. extraction and processing units. Currently, these units are powered by diesel or gas generators.

Geothermal energy

Geothermal energy is energy that has been coming from the inner layers of the Earth for many millions of years. According to the most reliable data, the temperature inside the Earth's core reaches about 3000-6000 degrees Celsius, decreasing

from the center of the planet to its surface layer. The existence of an infinite amount of energy inside the planet is evidenced by volcanic eruptions, which extract energy directly from the Earth's crust and mantle.

The core of our planet has such a temperature due to the presence of uranium, thorium and radioactive potassium, which participate in the processes of radioactive decay. In the oceans, these processes occur in the upper part of the mantle, and on land, the elements decay at a depth of twenty or more kilometers in the granite layer of the earth's crust. Geothermal energy will develop only in areas of seismic and volcanic activity, since there it comes to the surface of the Earth. Countries such as Iceland, New Zealand, the USA, Russia, Italy, Japan, the Philippines, El Salvador and Mexico actively use volcanic energy and develop it.

Geothermal energy sources can be divided into 3 types:

1) hot dry steam;
2) hot wet steam;
3) hot water directly from the source (geyser).

Using the heat of the earth's interior allows us to replace depleted reserves of oil and natural gas. There are four general types of geothermal energy resources:

• heat extracted from the Earth's surface.

• energy of condensation of warm and hot water, as well as steam, which can be used in the production of electrical energy.

• heat located and concentrated deep within the Earth.

• volcanic energy and heat, as well as the energy of magma.

Due to frequent seismic activity from volcanoes in different parts of the world, a plan is currently being developed to use the energy from volcanoes to generate heat, which will help reduce the cost of placing other energy-type facilities to heat nearby cities.

14.2. The concept of bioenergy. Use of biomass energy in the world and in the Republic of Belarus. Biogas

Bioenergetics.

Bioenergy is the creation of energy from all kinds of biological fuel. With the increase in the rate of consumption of biological fuel, the problem of recycling industrial and household organic waste arises. Due to the fact that waste such as this contains a large amount of carbon in the form of hydrocarbons, they are a potential energy resource.

However, direct combustion technologies are used in rare cases, primarily because the heat production from a large volume of resource is minimal, and environmental pollution is maximum compared to other existing energy resources.

Biogas production, albeit by semi-artisanal methods, is developing most in China, where there are tens of millions of biogas plants designed for one family; the number of such plants is also growing rapidly in India, in the regions of Southeast Asia and Central America, and in the CIS countries.

such raw materials as ethyl alcohol is increasing . The largest producer on Earth is Brazil. Most of its vehicle fleet runs on either pure ethanol or alcohol-gasoline mixtures.

The most common methods of using biomass are:

1. Direct combustion.
2. Pyrolysis.
3. Gasification.
4. Anaerobic fermentation with methane formation.
5. Production of alcohols and oils for fuel production.

Belarus is favorable for the development of bioenergy, since most of its territory is covered with green cover - forest, and also due to the presence of modern energy engineering companies, well-developed infrastructure for the distribution of heat energy, the presence of a flat landscape, and also due to the high level of technical education of the population.

The following are used as biological fuel:

1. Wood biomass.
2. Wood waste generated during felling or processing of material.
3. Biological mass of fast-growing shrubs and herbaceous plants.
4. Lignin.
5. Combustible part of municipal waste.
6. Waste obtained during clearing of land for construction or land reclamation.
7. Plant waste.

The following have significant potential for use as biofuel in the Republic of Belarus:

1. Wood and its waste in the form of shavings, bark and other materials remaining after processing.
2. Biological gas.
3. Various wastes, including those from life activities, beet press, manure and many other components. They are used as fertilizers in agriculture. Their use allows to reduce the introduction of chemical fertilizers and reduces the load on groundwater. Thus, an environmental problem is prevented.

Wood accounts for the largest part of biofuel, which is involved in the balance of energy and fuel for the production of heat and electricity. Approximately 42% of the area of Belarus is covered by forests, and the reserves of unprocessed wood are more than 1.2 billion m^3. All this indicates a high potential for the production of biofuel.

Biogas is produced by fermentation of biomass. Biomass is a material made from the remains of plants and animals. Biomass is broken down into components by bacteria of three different types:

- A chemical reaction between carbohydrates, salts or proteins and water, producing hydrolytic bacteria.
- Acid-forming bacteria.
- Methane-producing bacteria.

In this sequence, bacteria absorb the waste products of the previous ones (methane-forming bacteria feed on acid-forming bacteria, and they in turn feed on hydrolytic bacteria). All these bacteria produce biogas. The creation or production of biogas helps prevent methane emissions into the atmosphere. Methane affects the greenhouse effect much more strongly than CO_2. It is in the layers of the atmosphere for about 11-13 years. Therefore, methane capture is the fastest way to prevent global warming.

Biogas is increasingly used in various countries. It is obtained by fermentation of organic waste (garbage, manure, sewage, plant waste, etc.). Biogas is the fuel for more than a million factories in China. In Japan, landfills of various household waste are used to produce biogas. The production of 15 m^3 of gas can provide fuel for a power plant with a capacity of approximately 700 kW.

The anaerobic fermentation of various wastes from large livestock complexes solves the most important problem of environmental pollution. All wastes are processed into excellent fertilizers or biogas. A unit of cattle produces approximately 1 m^3 of biogas.

The largest biogas plant in Belarus is located in Trostenets. It has a capacity of about 2 MW and is capable of providing energy to more than 50 thousand people.

Control questions

1. Name the renewable energy sources.
2. What is the working principle of a solar battery?
3. Describe the advantages of obtaining electricity from the sun and wind?
4. Describe the thermal energy of the ocean.
5. What is the operating principle of wave power plants?
6. Please describe geothermal energy?
7. Which renewable energy source, in your opinion, is the most promising for the Republic of Belarus?
8. What is bioenergy? What potential for further development of bioenergy does the Republic of Belarus have?
9. What methods of using biomass in bioenergy do you know? Are there any biomass power plants in Belarus?
10. Describe the method of obtaining and prospects for using biogas.

5. Labor protection

Lecture 15. Legislation of the Republic of Belarus in the field of labor protection. Ensuring protection from hazardous and harmful production factors

Lecture plan:

15.1. Law of the Republic of Belarus "On Labor Protection". Main directions of state policy in the field of labor protection in the Republic of Belarus. Responsibility for violation of labor protection legislation.

15.2. Duties and rights of the employer in the field of labor protection. Duties and rights of the employee in the field of labor protection. Labor protection instructions.

15.3. The concept of harmful and hazardous production factors, their classification and brief characteristics. Classification of working conditions. Principles, methods and means of ensuring the safety of workers.

15.1. Law of the Republic of Belarus "On Labor Protection". Main directions of state policy in the field of labor protection in the Republic of Belarus. Responsibility for violation of labor protection legislation

The basic principles of labor protection are established by **the Law of the Republic of Belarus of 23.06.2008 No. 356-Z "On Labor Protection".**

Occupational safety and health includes a set of measures aimed at protecting the life and health of workers.

Responsibility for violation of labor protection legislation includes: disciplinary (reprimand, reprimand, dismissal), administrative (fine from five to forty basic units for violations), and capital (imprisonment for up to seven years for violation of rules resulting in the death of two or more persons).

15.2. Duties and rights of the employer in the field of labor protection. Duties and rights of the employee in the field of labor protection. Labor protection instructions

The employer's responsibilities for labor protection: ensuring the safety of the territory, buildings and equipment, monitoring protective equipment, insuring workers, compensating for damage caused to the health of workers, taking measures to prevent accidents, etc.

Employer rights: demand compliance with occupational safety standards; reward compliance; conduct alcohol testing; request information about injuries; contact authorities; make proposals for changing standards.

Employees' responsibilities regarding occupational safety: undergoing training; fulfilling occupational safety requirements; caring for safety; using protective equipment; reporting accidents.

Workers' rights: participation in briefings; receiving information about working conditions; participation in safety discussions; provision of protective equipment; refusal to work if life is at risk.

Labor protection instructions are local regulations that include labor protection requirements. Instructions are developed on the basis of standard instructions, and employers without the right to approve local documents are guided by standard instructions.

15.3. The concept of harmful and hazardous production factors, their classification and brief characteristics. Classification of working conditions. Principles, methods and means of ensuring the safety of workers

A harmful production factor is a production factor that leads to illness, decreased performance or death.

A hazardous production factor is a production factor that leads to injury or death.

They are related. For example, high humidity and conductive dust (harmful factors) can increase the risk of electric shock (hazardous factor).

Harmful and hazardous production factors are classified into physical, chemical, and biological.

Physical factors include dust load, acoustics, microclimate, light environment, electromagnetic fields and radiation, etc.

Chemical factors include substances that cause acute poisoning, carcinogens, allergens, antitumor drugs, hormones, narcotic analgesics, etc.

Biological factors include: pathogenic microorganisms, bacterial preparations, etc.

The factors of the work process are the severity of the work process (lifting and moving heavy objects, working posture, body bending, movements in space due to the technological process, etc.) and the intensity of the work process (intellectual loads, sensory loads, emotional loads, monotony of loads, work schedule).

Working conditions are a set of factors in the production environment that affect the health of the worker during the course of work.

Principles of hygienic classification of working conditions:

1. Differentiation of levels of deviations of harmful and hazardous production factors from hygienic standards.

2. Distribution of working conditions according to certain classes.

Classes of working conditions:

1. **Optimal working conditions (class 1)** – factors that maintain the health of workers.

2. **Acceptable working conditions (class 2)** are factors that do not exceed legislative standards. Possible changes in the body's condition are restored by the beginning of the next shift and do not have a negative impact on the health of workers and their offspring.

3. **Harmful working conditions (class 3)** are factors that exceed hygienic standards and have an adverse effect on the health of workers and their offspring.

4. **Hazardous working conditions (class 4)** are factors that significantly exceed standards and can lead to a high risk of developing severe acute occupational diseases.

Ensuring industrial safety includes principles, methods and means that can be divided into four groups:

1. Guiding principles

- The principle of humanization of activity is a focus on human safety.
- The principle of systematicity is taking into account all factors that contribute to accidents and illnesses.
- The principle of destruction is the destruction of a dangerous system by eliminating one of its elements (for example, reducing the temperature to prevent spontaneous combustion).
- The principle of hazard reduction is the use of measures when complete elimination of hazard is impossible (for example, speed limitation).
- The principle of hazard elimination is the elimination of harmful factors (implementation of safe equipment).

2. Technical principles

- The principle of strength is to increase the safety of materials and structures.
- The principle of protection by distance is to increase the distance from the source of danger (for example, fire breaks).
- The principle of shielding is the use of protective screens against noise, vibration and radiation.

3. Organizational principles

- The principle of time protection is to reduce the time spent in the area of harmful factors.
- The principle of standardization is the regulation of working conditions (for example, the maximum permissible concentration of harmful substances).
- The principle of ergonomics is the design of equipment and work places taking into account human characteristics.

4. Management principles

- The principle of planning is the development of areas of activity and quantitative indicators.
- The principle of compensation is the provision of benefits for work in unfavorable conditions.
- The principle of efficiency is a comparison of actual and planned results and an analysis of the achieved indicators.

Methods of ensuring employee safety during work activities:

1. Distinction between the homosphere and the noxosphere .

- **Homosphere**: the work area where a person is located.

- **Noxosphere**: a space with harmful or dangerous factors.
- Methods: organization, automation, remote control, etc.

2. Normalization of the nocosphere *(*elimination of harmful and dangerous factors using collective means of protection).

3. Adaptation of a person to the noxosphere (training, instruction, use of personal protective equipment).

Means of ensuring the safety of workers.

Collective protection means: fences, braking devices, alarms, remote control devices, ventilation and heating, safety signs, etc.

Personal protective equipment: respiratory protection, insulating suits, special clothing, head, eye, face, hand protection, safety devices, protective dermatological products.

Control questions

1. Give a definition of the term "Labor protection".
2. What types of liability are provided for violation of labor protection legislation?
3. What rights and responsibilities does an employer have in the area of occupational safety?
4. Name the main rights and responsibilities of an employee in the field of labor protection.
5. Provide a definition of the term "Occupational safety instructions". What requirements does this document contain?
6. Provide a classification and description of harmful and hazardous production factors.
7. Formulate a definition of the concept "Working conditions". What classes are they divided into?
8. Name the principles of hygienic classification of working conditions.
9. Describe the principles of ensuring worker safety.
10. List three methods to ensure employee safety during work activities.
11. Describe the security measures working.